Aerial Photography Evaluation of Sugarbeet Experimental Plots Infected with Rhizoctonia solani

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INTRODUCTION

Crown rot caused by the soil-borne fungus *Rhizoctonia solani* Kuehn, is an important disease of sugarbeet (*Beta vulgaris* L.) throughout the United States. The disease is characterized by a progressive rotting of crown and root tissue. Symptoms include yellowing and wilting of foliage, black discoloration of petioles near the crown, and transformation of the foliage bouquet to a rosette of prostrate dry leaves which persist throughout the growing season.

Inasmuch as aerial photography has been successfully used to evaluate root rot damage in cotton (2) and *Aphanomyces* root rot damage in sugarbeet (4), we investigated its possible utility for evaluating our experimental plots of sugarbeet breeding lines, chemical treatments and agronomic practices that differed considerably in crown rot incidence and severity. A preliminary report of our 1974-75 studies has been presented (5). We now describe methods used in our investigations and summarize the results of our photo interpretation studies involving nine experimental plantings.

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MATERIALS AND METHODS

Field plots - The experimental plot areas were of two main types: 1) *Rhizoctonia* nurseries of 1974-77, 1979, 1981 at the Michigan Agricultural Experiment Station, East Lansing, where plots were artifically infested with *R. solani*; 2) Cropping sequence experiments of 1978-79 and 1981 conducted by D. Christenson of Michigan State University Crop and Soil Sciences Department at the Saginaw Valley Beet and Bean Research Farm, Michigan, where plots were exposed to natural infestations of *R. solani*.

The *Rhizoctonia* nurseries comprised plots of sugarbeet breeding lines that varied in susceptibility to crown rot, and plots of commercial cultivar, US H20, treated with various fungicides for control of the disease. Plots were of 5-m length in 1974-77 nurseries and of 7-m length in 1979, 1981 nurseries. Row spacing was 71.1 cm. Each nursery comprised 4-9 experiments of 9-61 entries and 3-6 randomized blocks. Shortly after plants were thinned to one/21 cm in late June or early July, plots were infested with dry grain inoculum of *R. solani* as described previously (3).

The cropping sequence experiments, of 2.5 ha, included, in addition to several other crops, 40 plots of commercial sugarbeet cultivar US H20. Each plot comprised eight 20.1-m rows spaced at 71.1 cm.

Crown rot symptoms in both types of plots usually appeared within eight weeks after planting and the disease continued to develop throughout the growing season. When the crop was at or near maturity, plots were evaluated according to incidence and severity of crown rot, expressed in percent, as previously described (3). In the 1974-77 nurseries and crop sequence plots, disease determinations based on above-ground symptoms of crown rot were made prior to harvest. In the 1979 and 1981 nurseries, ratings were made after the roots had been harvested.

Photographic equipment - Thirty-five mm transparencies were obtained on IR Ektachrome film with a Nikkomat camera equipped with a 50 mm lens and Wratten 12 filter. Seventy mm transparencies were obtianed on Kodak Aerochrome IR film with a Hasselblad camera equipped with an 80mm lens. The cameras, attached to the outside of a Cessna 172 aircraft, were equipped with motor-driven film advance mechanisms.

Photo evaluation of plots - Transparencies were obtained of six *Rhizoctonia* nurseries at altitudes of 240-360 m and of three crop sequence experiments at altitudes of 550-760 m. Pertinent information concerning each photograph is presented in Table 1.

The transparencies were viewed with a 32X microfiche reader (Bell and Howell SRVIII) on a 27.5 x 27.5 cm ground glass screen. The lengths of individual plots on the screen were 12-59 mm for *Rhizoctonia* nurseries, and 40-113 mm for crop sequence experiments.

In preliminary studies it was apparent that individual plant symptoms used in ground-based determinations of crown rot intensity, were not readily discernible in the photographs. On the other hand, differences in plot phytomass density indicating differences in stand and foliage development associated with various levels of disease intensity were readily discernible. In some photographs color differences among plot images were also discernible and varied from deep red, light red, pink, and white as disease intensity symptoms ranged from none to moribund. Foliage of dead plants appeared brown or black in some photographs but was not discernible in others.

A method of rating photo images of plots was developed on the assumption that phytomass density tends to vary inversely with crown rot intensity with other stress factors negligible. Each plot image was rated as to degree of phytomass development according to the following index: 1-3 (none-sparse); 4-6 (intermediate); 7-9 (high-luxuriant) Stand, foliage density and, in some cases, foliage color were considered in rating assignments.

In photographs of the *Rhizoctonia* nurseries (Nos.1-6)

Table 1. Information pertaining to IR color transparencies of sugarbeet plots exposed to the crown rot fungus, *Rhizoctonia solani*.

Photograph No.	Location[1]	day-mo.-yr	Scale	Altitude (m)	Angle	Transparency size (mm)	Plot area (ha)
1	RN	28-8-74	1:4710	235	vertical	35	0.30
2	RN	26-8-75	1:7270	265	vertical	35	0.22
3	RN	23-8-76	1:5620	280	vertical	35	0.19
4	RN	4-8-77	1:7000	350	vertical	35	0.42
5	RN	18-9-79	1:4550-5690	250	oblique	35	0.16
6	RN	15-9-81	1:4670	375	vertical	70	0.60
7	CS	20-8-78	1:11030	550	vertical	35	0.46
8	CS	18-9-79	1:15500-15930	800	oblique	35	0.46
9	CS	15-9-81	1:5680	455	vertical	70	0.46

[1]RN = *Rhizoctonia* nursery, with plots artifically infested with *R. solani*, CS = crop sequence study, with plots naturally infested.

each one-row plot was rated except those containing fewer than 6 plants before inoculum was applied. In photographs of the cropping sequence experiment (Nos. 7-9), a mean rating was assigned for the 4 middle rows of each plot.

RESULTS

Field and photo ratings compared - A total of 4536 plots were rated among the nine photographs. Field ratings, expressed as percent crown rot, were compared plot by plot with photo ratings for each photograph and the corresponding correlaton coefficient was calculated. The distributions of mean photo ratings at each crown rot intensity level indicate a negative and straight line relationship between the two ratings (Fig. 1).

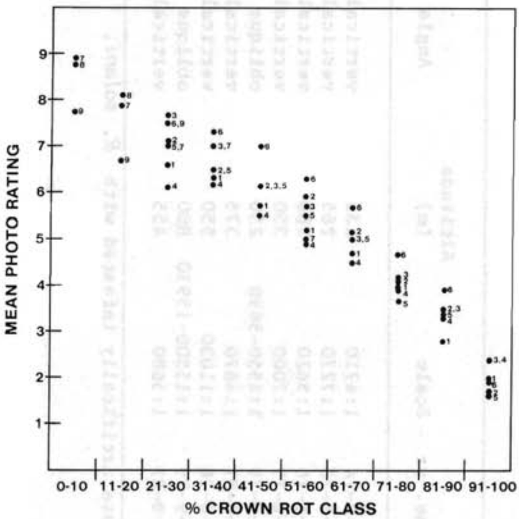

Figure 1 - Distribution of mean photo ratings, indicating degree of plot phytomass development, from 1 (none) to 9 (luxuriant) in each crown rot intensity class. Numerals at each data point indicate photograph number, as described in Table 1, from which determinations were made.

Photo ratings of plot images in all but one of the nine photographs showed highly significant negative correlations with crown rot ratings, in most cases at or below the 1% level (Table 2). In regard to the rating comparisons of photographs no. 8 and 9, that had low correlation coefficients (-.15 and -.37, respectively), factors other than crown rot may well have affected phytomass production, especially in regard to stands. Correlation coefficients of stand/photo rating comparisons of plots included in photographs no. 8 and 9 were .59** and .57**, respectively, whereas there was no significant correlaton between stand and percent crown rot within plots.

Table 2 - Association of crown rot intensity ratings and photo ratings of sugarbeet plots exposed to *Rhizoctonia solani*.

Photograph No.	No. plots compared	Crown rot (pct)		Photo rating[1]		Correlation[2] coefficient
		Mean	Range	Mean	Range	
1	840	44.9	25.0-95.8	5.7	1-9	-.66**
2	629	62.4	25.0-100	4.9	1-9	-.75**
3	504	59.0	25.0-100	5.3	1-9	-.76**
4	1078	76.5	28.1-100	3.7	1-8	-.62**
5	631	42.4	25.0-100	6.1	1-9	-.65**
6	734	57.6	26.8-94.0	6.1	1-9	-.69**
7	40	8.6	0.0-58.9	8.6	5-10	-.94**
8	40	5.8	0.7-19.4	8.7	8-9	-.15
9	40	4.4	0.0-22.0	7.7	6-9	-.37**

[1]Photo ratings, expressing relative phytomass density per plot, are based on an index from 1 (none) to 9 (luxuriant).
[2]Coefficients indicated by * and ** are significant at 5% and 1% levels, respectively.

Stress factors, other than crown rot, also affected photo ratings of photograph no. 4. In the westernmost portion of the field, consisting of 47 rows of plots in five tiers, most of the plants showed symptoms indicating extremely low soil fertility including unthrifty growth and chlorosis. These symptoms were noted before the plots were infested and had been observed in the same area in prior years. As expected, the correlation between field and photo ratings in this portion of the field was considerably lower (r = -.48**) than in an adjacent area of comparable size (r = -.70**) where symptoms of the physiological disorder were not noted.

Variability and statistical significance of field crown rot and photo ratings compared - Coefficients of variation (standard deviation in percent of general mean) (CV) were calculated from crown rot and photo rating data of each of the 38 experiments included in the nine photographs of this study. Means and ranges of CVs of the 34 experiments included in photographs 1-6 of the crown rot nurseries and of the three experiments included in photographs 7-9 of the crop sequence study were as follows:

Photograph nos.	Crown rot rating CV	Photo rating CV
1-6	20.0 (9.5-30.8)%	23.6 (13.0-45.4)%
7-9	58.9 (44.9-74.9)%	8.1 (7.4-8.8)%

Among the 38 experiments, there were 29 in which the F-test indicated significant differences in crown rot ratings among entries. Of these 29 experiments, there were 23 (79.3%) with significant differences in photo ratings among entries. Likewise, there were 19 experiments with significant differences in crown rot ratings among blocks, of which 16 experiments (84.2%) also showed significant differences in photo ratings.

DISCUSSION

Our studies show that differences in phytomass density among sugarbeet plots exposed to *R. solani* can be detected in aerial photographs. In addition, with other stress factors minimal, phytomass density was negatively correlated with crown rot intensity. Aerial photographs provided a useful record of differences in phytomass density atributable to *Rhizoctonia* crown rot intensity level among breeding lines, fungicide treatments, and randomized blocks in field experiments. Furthermore, the distribution pattern of areas within an entire field that differ in crown rot intensity can often be determined more readily from aerial photographs than from ground observations.

Variability in photo ratings, as indicated by coefficients of variation in 38 experiments, did not greatly exceed that which occurred in field crown rot ratings. In the cropping sequence experiments, CVs of photo rating data were considerably less than those of crown rot data, probably because of low, non-uniform disease incidence and occurrence of other factors that affected stands.

Inasmuch as phytomass determinations are affected in part by foliage vigor, it is possible that our photo ratings may have been affected by inherent differences in foliage vigor among entries. The effect was probably minor since there were not apparent large differences among entries in this respect. However, in cases where there are large differences, as when inbred lines and hybrids are compared, genetic differences in foliage vigor would have to be taken into account in making aerial photo evaluations.

On the basis of our results, further studies on use of aerial photography in sugarbeet crown rot research appear warranted, especially in regard to techniques for improving the precision of photo ratings and the determination of maximum plot area permitting effective photo evaluation. In regard to the first objective, the use of a densitometer, as reported by Jackson et al. (1) in photographic determination of photo late blight intensity level, offers promise of reducing human error. In regard to the possibility of increasing the size of photographed plot areas, it should be emphasized that the plot areas in our study, ranging in size from approximately 0.2 to 0.6 ha, comprised but a fraction of the total area of each photograph. At the altitudes employed, it is assumed that plot areas 6 to 20 times larger could easily have been accommodated.

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