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SECTION 124

CORN BLIGHT WATCH EXPERIMENT RESULTS

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

by

C.J. Johannsen, M.E. Bauer, and Staff*
Laboratory for Applications of Remote Sensing (LARS)
Purdue University
West Lafayette, Indiana

Many results were obtained from an experiment as large as the Corn Blight Watch Experiment. This discussion will concentrate on results pertaining to the detection and assessment of the severity and extent of southern corn leaf blight in the Corn Belt area by ground observations, interpretation of color infrared photography, and machine analysis of multispectral scanner data.

GROUND OBSERVATIONS

Biweekly ground observations provided comprehensive information on the development of SCLB in 1971. The sample design enabled the ground observation data from 8-10 biweekly fields to be expanded to estimate acreages of corn in each blight severity level for each segment, flightline, and total seven-state area. These estimates are highly accurate for the entire experimental area and the intensive study area and less accurate at the flightline and segment levels.

Estimates of proportions of acres in each blight severity class for the eight biweekly observation periods are summarized in Figure 1. In June and July blight was widespread across the Corn Belt area, but Figure 1 indicates that it was restricted to a small acreage and the severity levels were quite low. By early August a significant portion of the acreage was infected at the low blight levels of 1 and 2 and about five percent of the acreage had moderate (level 3) infection. From this time on the extent and severity of infection depended on weather conditions occurring during the remainder of the season.

There was an increase in the acreage becoming infected during mid-to late-August, but only 20 percent of the acreage was infected at moderate or severe levels (levels 3 or 4) and less than five percent

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was very severely infected (level 5) by the last week of August. By this time most of the corn was at the dent stage of maturity and further increases in infection level had little or no effects on yields. During the last two observation periods higher infection levels were reported; however, some of these estimates may have been conpounded by the effects of normal maturity and senescence, making it difficult to accurately rate blight damage alone in the field.

INTERPRETATION OF COLOR INFRARED PHOTOGRAPHY

The photointerpretation results can best be examined by comparing the photointerpretive estimates of blight severity with those made from ground observations. The first level of comparison will be estimates of the total number of acres in each blight severity level for the entire experimental area (Figure 2). There is close agreement between the two estimates at all blight levels except 0 and 1. The higher number of acres of blight level 0 estimated by photointerpretation indicates that slightly infected corn could not be distinguished from corn with no infection using photointerpretation techniques, therefore corn with level 1 infection was probably called blight level 0 (healthy corn) in many cases. Preliminary examination of the variances of these estimates shows that variances for field and photointerpretive estimates are of similar magnitude.

Photointerpretive and field observation results can also be compared at the flightline level. At the same time the variables geography and time can be observed since we will be looking at maps showing the location of different blight infection levels at several times during the season. The average blight severity level for each flightline according to ground or photointerpretative estimates was computed from the expanded acreage of corn in each blight level in the flightline. The range of estimated blight severity levels was divided into four classes for presentation. Figures 3 to 6 make these comparisions for the periods beginning July 26, August 9, August 23 and September 6.

The estimated average blight severity for field observations during the July 26-August 8 period was less than 1.50 for every flightline. Photographic data from the 14 available flightlines showed good agreement with the ground data in that 13 of 14 flightlines had estimated blight levels less than 1.50 (Figure 3). The remaining flightlines were not flown due to aircraft mechanical problems and unfavorable weather.

During the two week periods beginning August 9 (Figure 4) and August 23 (Figure 5) the photointerpreters tended to slightly overestimate the average blight levels relative to ground estimates. This is largely due to the difficulty of distinguishing blight effects from effects caused by other factors which appear similar to blight damage on the infrared film. Some of these factors include other diseases, drought damage, insect damage, and nutrient deficiencies. Work is continuing to further quantify and similarities and differences in appearance of these factors on color infrared film.

Unfavorable weather prevented collection of photography over the eastern half of the area during the period from September 6-19 (Figure 6). For those flightlines where comparisons can be made, there is good agreement between ground observations and photointerpretation results.

Although ratings of blight severity were made in many fields across the Corn Belt, an average of only eight fields per segment were checked on the ground. Most of these fields were used for training. To make the best tests of classification accuracies, ratings would be needed from many more fields so that field by field comparisons could be made. However, only a limited number of fields are available for this kind of test. Therefore, other kinds of statistical analysis have been used to evaluate the classification results. One of the procedures used was correlation. Correlation is a quantitative measure of the degree of agreement between the two methods, both of which are known to be subject to experimental error. Close agreement between field observations and photointerpretation (or machine analysis of multispectral scanner data) means that the two methods are estimating the same value for the parameter.

To more quantitatively illustrate the same data shown on the previous maps, plots of field observation estimates versus photointerpretive estimates are presented in Figure 7 for two periods. Segment means are shown in Figure 7 whereas flightline means were shown in Figures 3,4,5, and 6. Note that there is an increase in the correlation coefficient (r) for the later period when more levels of blight were present. The 1:1 line is shown as an aid in determining when there is good agreement between the two methods; it should not be confused with a regression line. Perfect agreement between the two methods would result in all points falling on the 1:1 line. A consistent bias (either over-or under-estimation) would still result in high correlation.

A major objective of the experiment was to determine if healthy corn could be distinguished from diseased corn by remote sensing methods. The graph of correlations for two classes of blight severity (0-1-2 and 3-4-5) indicates that the corn fields could be accurately separated into the two classes, healthy or slightly blighted and moderately to severely blighted (Figure 8). The data points in Figures 8 and 9 represent acres of each blight severity class in a segment. Correlation coefficients of .90 and .64 were obtained for the two classes, respectively. Similar results were obtained for the segments in the intensive study area (Figure 9). There was a tendency, however, for photointerpretive results to underestimate the acreages in the healthy corn class and overestimate the acreages in the moderate to severe blight class as compared to ground estimates. Attempts to differentiate the six individual blight classes which can be distinguished on the ground were unsuccessful. This is indicated by the low correlation coefficients ($r = .21$ to $.67$), the "scatter" of the data points, and the large deviation from the 1:1 line (Figure 10). This is not surprising since differences between individual classes are subtle. The early stages of infection are confined to the lower leaves which are hidden from the view of the sensor.

Classifications into three groups (blight levels 0-1, 2-3, and 4-5) gave results intermediate to those shown here. Correlations were higher than for the six classes, but somewhat lower than for two classes.

Several photographic variables may have affected the photointerpretation results and complicated the task of blight assessment by photointerpretation. Examples of these variables are shown in Figure 11 for two segments. Changes in illumination conditions, haze, terrain features, and other factors could not be controlled. For example, the film was oversaturated for the flight period July 26-August 9. The problems encountered with film emulsions and changes in film batches were discussed by Blilie and are evident in the examples in Figure 11.

During the Experiment, the photointerpreters were requested to identify all the cover types occurring within a given tract in each segment for each flight period. The results from this analysis for segments in central Iowa are shown in Figure 12. The photography of segment 116 is typical of the photography for the area and is shown for comparison purposes. Corn was usually identified with over 90 percent accuracy for all mission periods. The accuracy of identifying soybeans increased, in general with each period. Identification of oats decreased after July 26 because the crop had been harvested. Pasture and hay crops varied in identification accurracy.

MACHINE ANALYSIS OF MULTISPECTRAL SCANNER DATA

In the intensive study area multispectral scanner data were collected along with ground observations and color infrared photography. A comparison of three methods of estimating the total acres in each blight class for the entire intensive study area is shown in Figure 13. The ground estimates and machine analysis estimates agree closely and have similar variances. Using photointerpretation techniques blight level 1 was greatly underestimated and blight level 3 overestimated compared to the other two methods.

The correlation of segment average blight levels as estimated by field observations and machine analysis of multispectral scanner data are shown in Figure 14 for four periods. During the earlier two periods fewer acres of moderate and severe blight were present and the correlation coefficients were relatively small. The variability may be due in part to the different procedures used by LARS and WRL in the analysis of this data.

There was much better agreement between the ground observations and machine analysis results for the two later missions as evidenced by the higher values (.86 and .90) and the close fit to the 1:1 line. As shown earlier for photointerpretation, the two earliest stages of blight infection are difficult to detect remotely.

The separation of fields into either healthy or blighted categories is shown in Figure 15. There is excellent agreement between the field observations and the estimates made from analysis of the multispectral scanner data. The data are the number of acres in each class for each of the 30 segments in the intensive study area. Correlation coefficients were .94 and .92 for the two classes and the points lie close to the 1:1 line. As with photointerpretive methods, attempts to classify the number of acres in each individual blight level were less accurate than for either two (Figure 16) or three classes.

There are many analyses which can be performed on data collected for the Corn Blight Watch Experiment. These analyses will be continued and results reported at future dates. There are many variables which can be evaluated for their effect on the results. Variables such as planting date, plant population, cytoplasm type and other stresses were not covered in this paper.

SUMMARY AND CONCLUSIONS

During the critical ear-filling period in August, ground observations showed there was little blight present in Nebraska, Minnesota, western and central Iowa, and the northern portions of Illinois, Indiana, and Ohio. The expansion of ground observations to total area, flightline, and segment estimates provided a basis for evaluating results from analysis of color infrared film and multispectral scanner measurements.

Healthy or slightly infected corn was accurately differentiated from moderately or severely blighted corn using photointerpretive techniques. Slight and mild levels of blight infection were not detected using the color infrared film. Variables such as soil differences, varietal differences and the presence of other stresses complicated the task of differentiating blight levels.

Accurate estimates of the acreages of healthy and blighted corn in the intensive study area were obtained from the machine analysis of the multispectral scanner data. There was high correlation and agreement between ground estimates and machine analysis estimates. Analysis of multispectral scanner data gave a more accurate assessment of the blight situation than that provided by photointerpretation methods when compared with expanded ground observations. Corn was identified with a high degree of accuracy by both photointerpretive and machine analysis methods throughout the season.

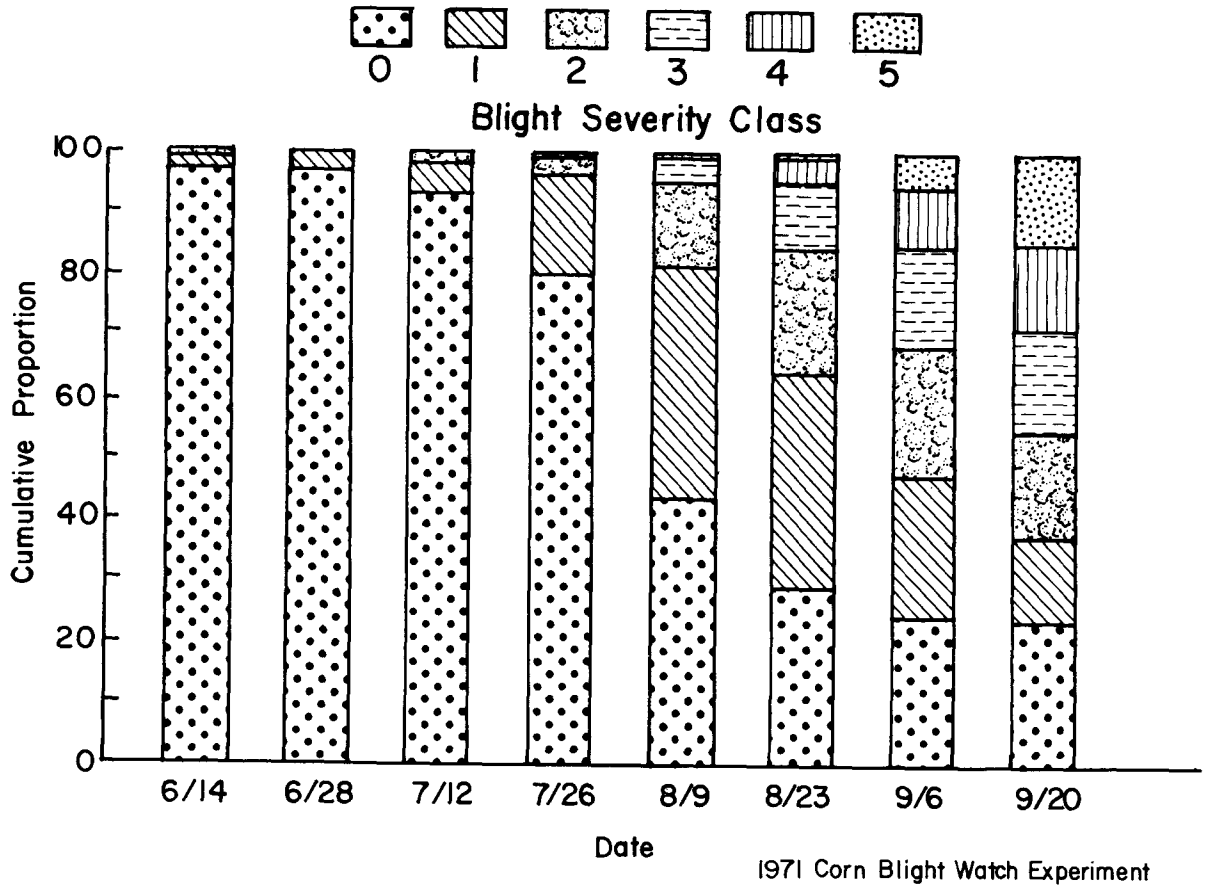

Figure 1. Proportion of acres in each blight severity class as estimated by ground observations for eight observation periods.

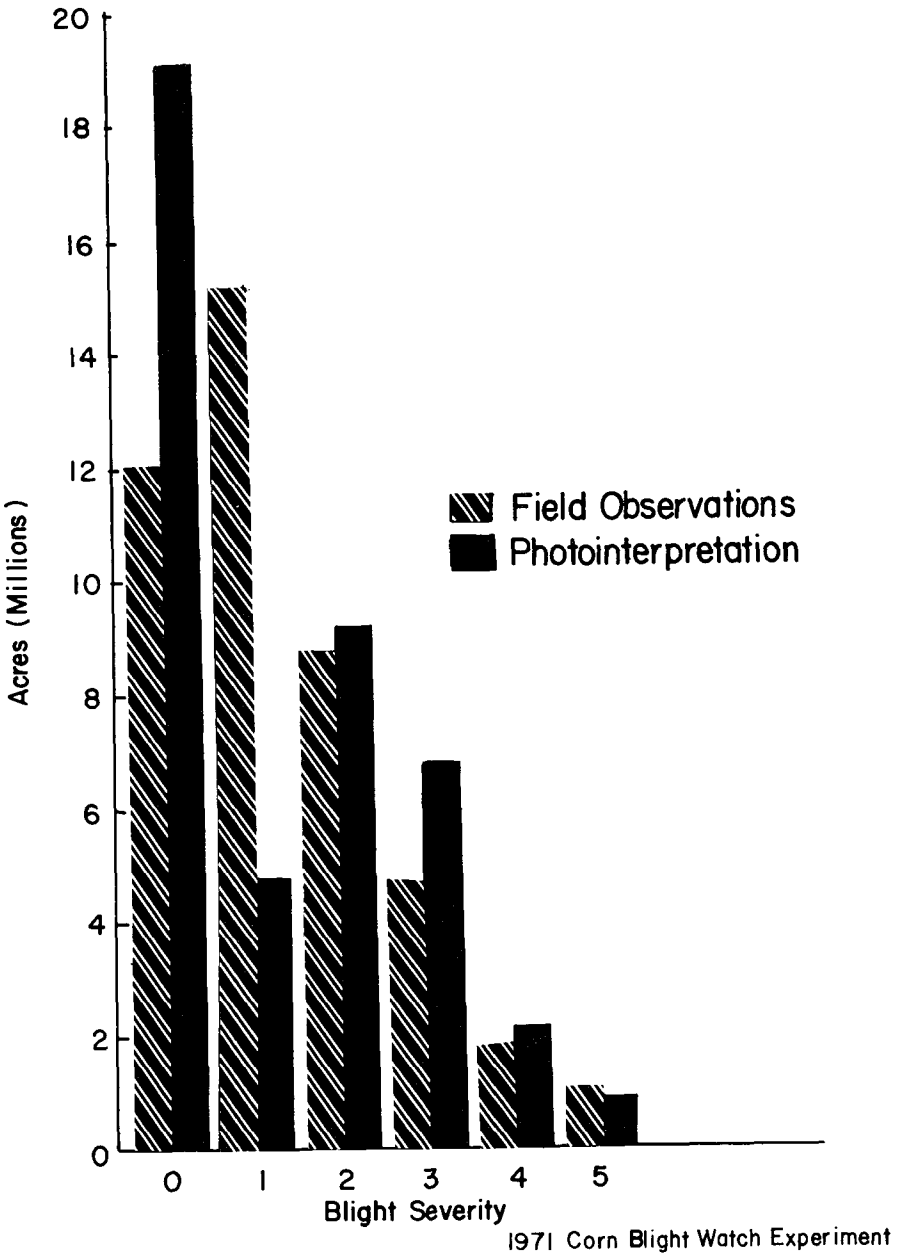

Figure 2. Comparison of field observation and photointerpretation estimates of corn acreage in individual blight classes for August 23 to September 5.

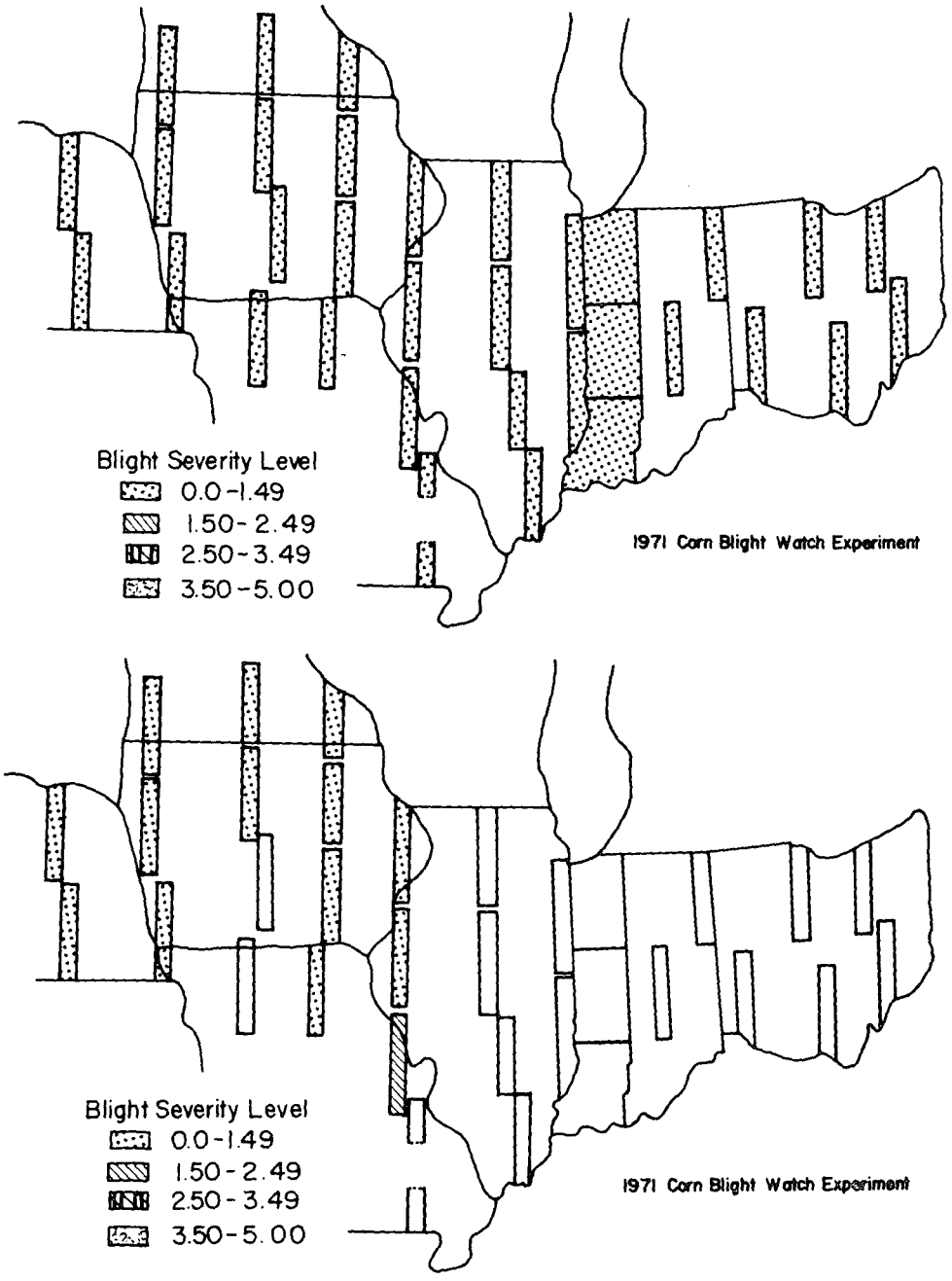

Figure 3. Average blight severity levels by flightline for field observations (top) and photointerpretation (bottom) for the period beginning July 26, 1971.

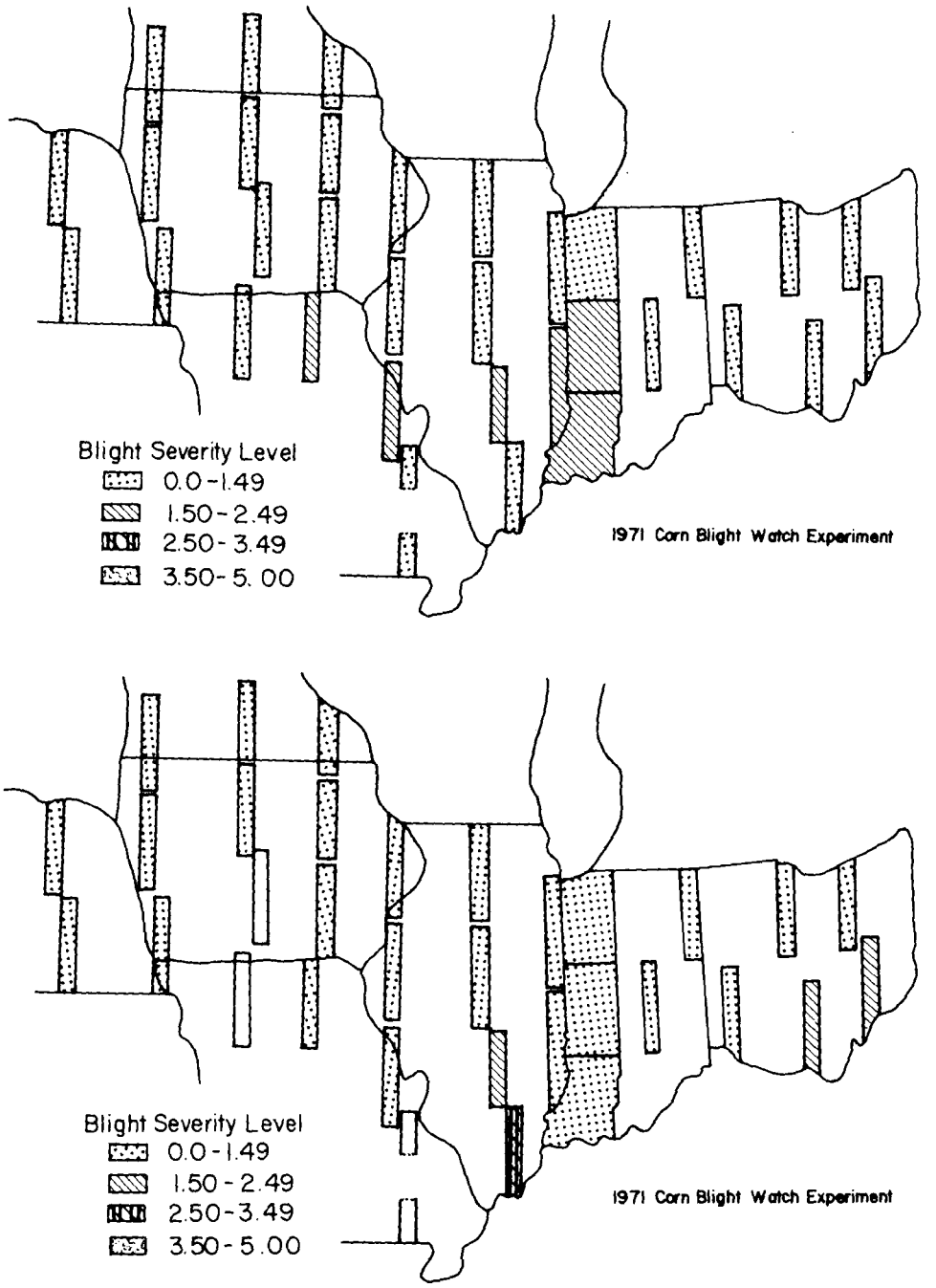

Figure 4. Average blight severity levels by flightline for field observations (top) and photointerpretation (bottom) for the period beginning August 9, 1971.

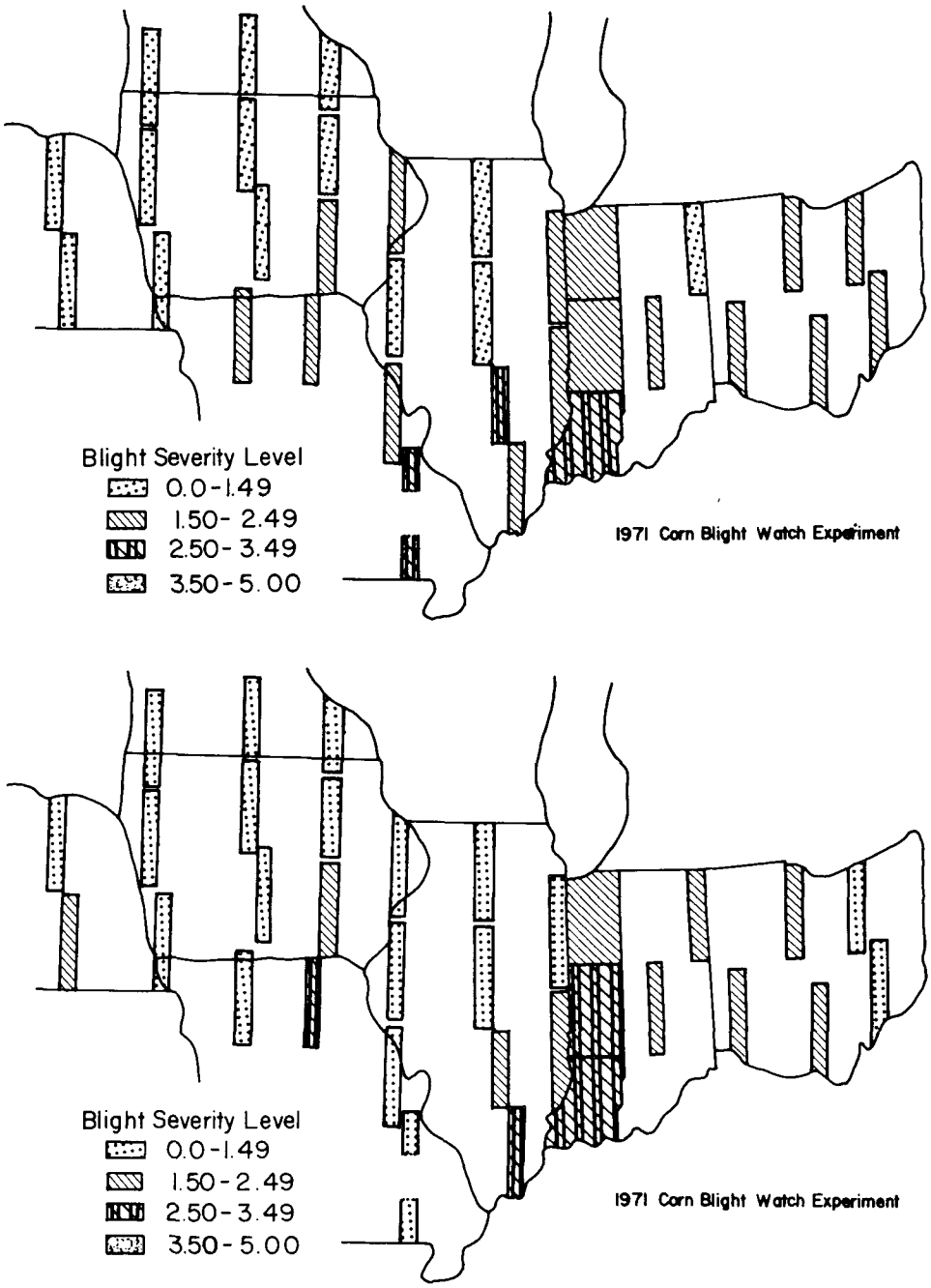

Figure 5. Average blight severity levels by flightline for field observations (top) and photointerpretation (bottom) for the period beginning August 23, 1971.

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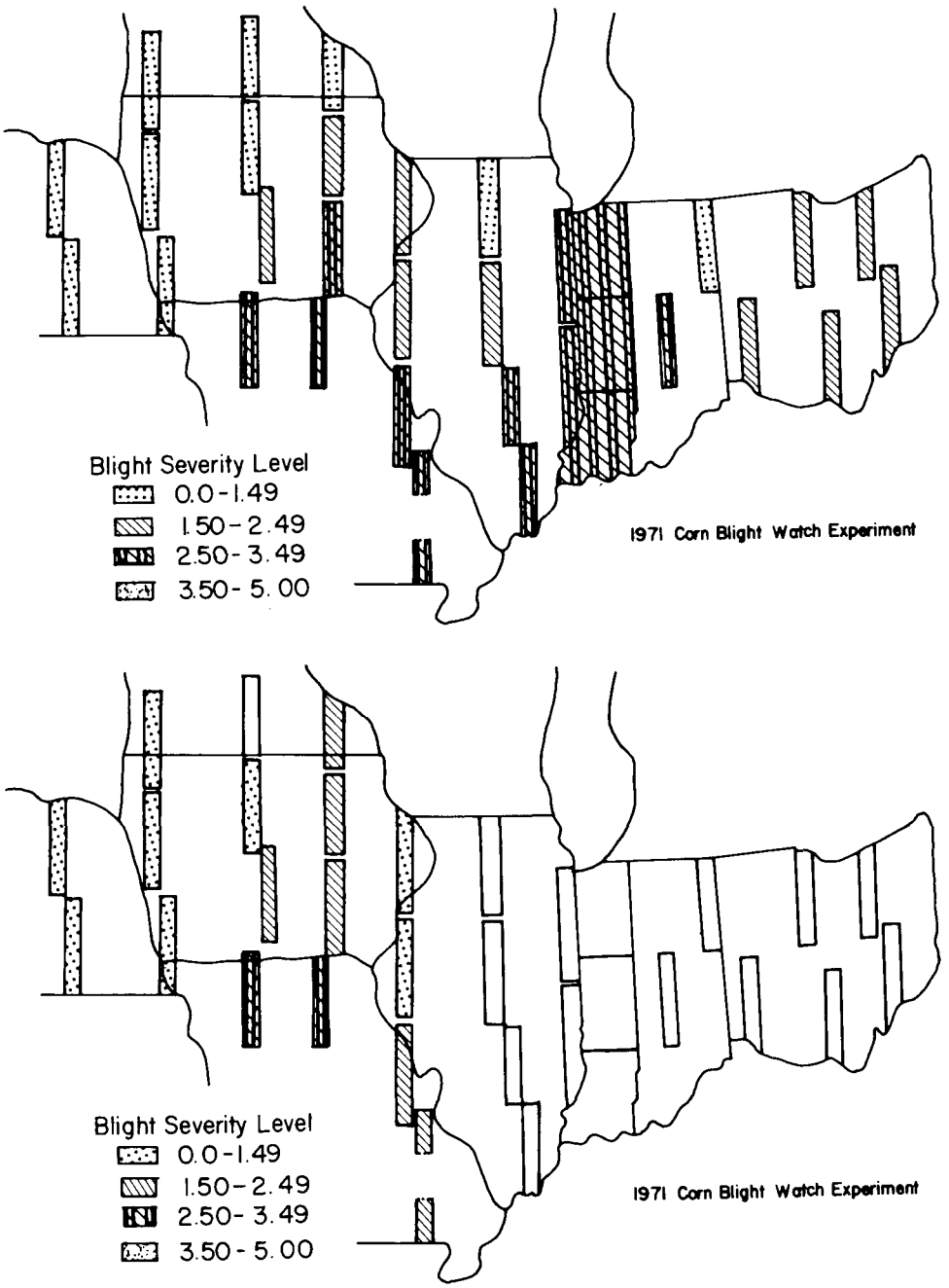


Figure 6. Average blight severity levels by flightline for field observations (top) and photointerpretation (bottom) for the period beginning September 6, 1971.

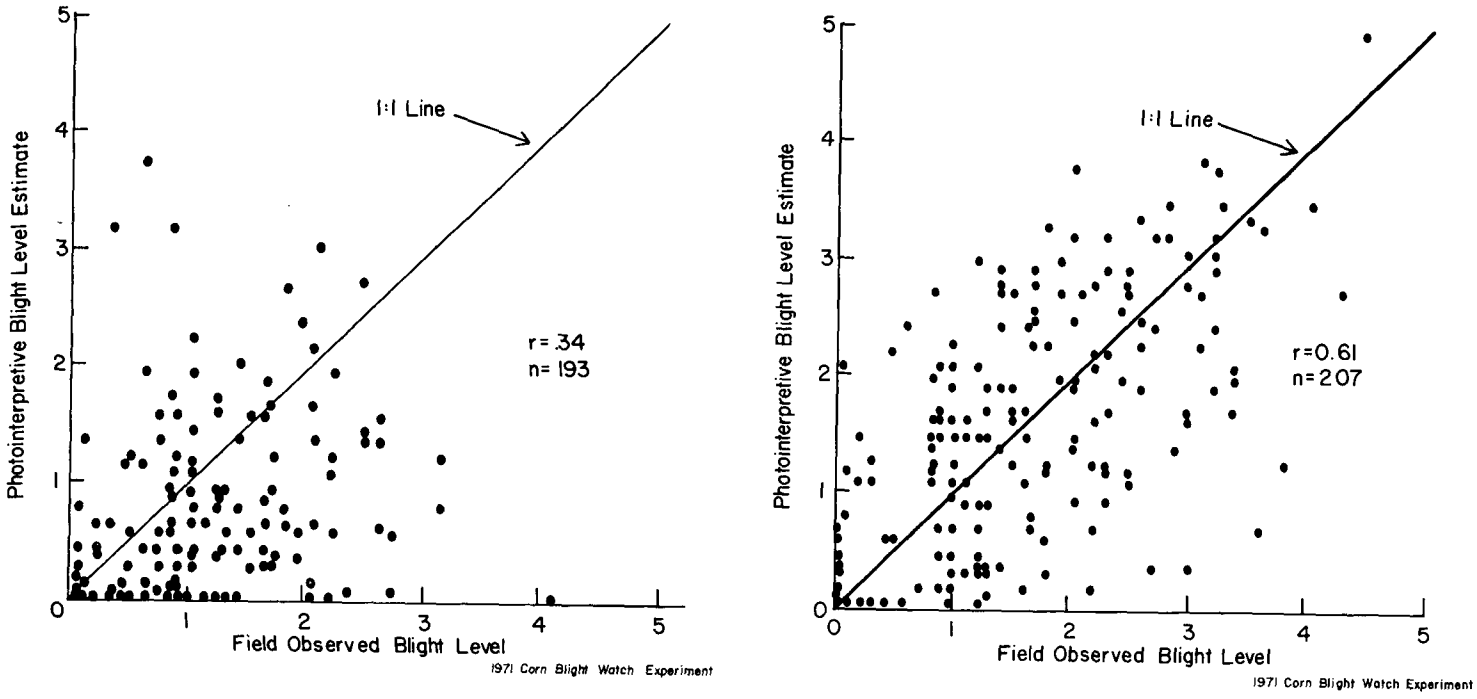


Figure 7. Correlation of field observation estimates and photointerpretation of segment averages of blight severity for the periods beginning August 9 (left) and August 23 (right), 1971.

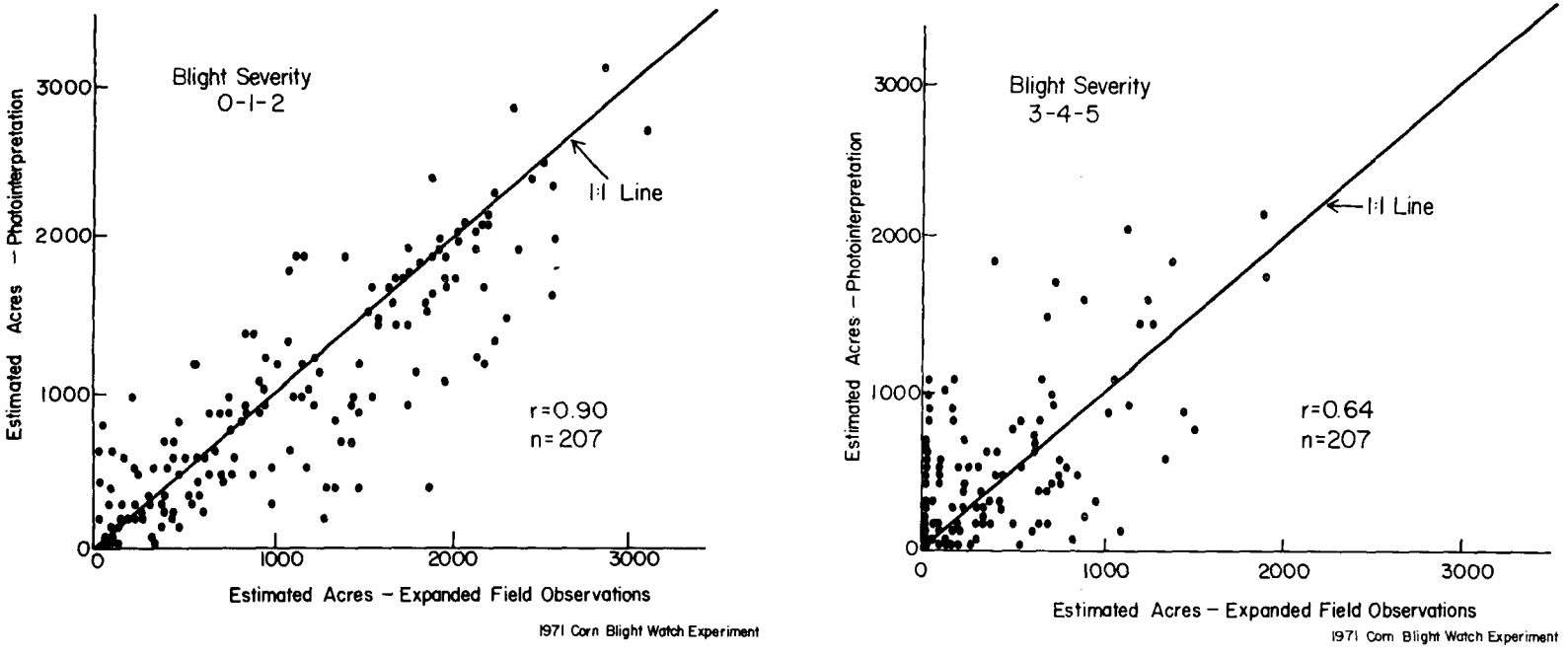


Figure 8. Correlation of field observation and photointerpretation estimates of acreages of healthy (blight levels 0-1-2) and blighted (3-4-5) corn in the Corn Belt area, August 9-22, 1971.

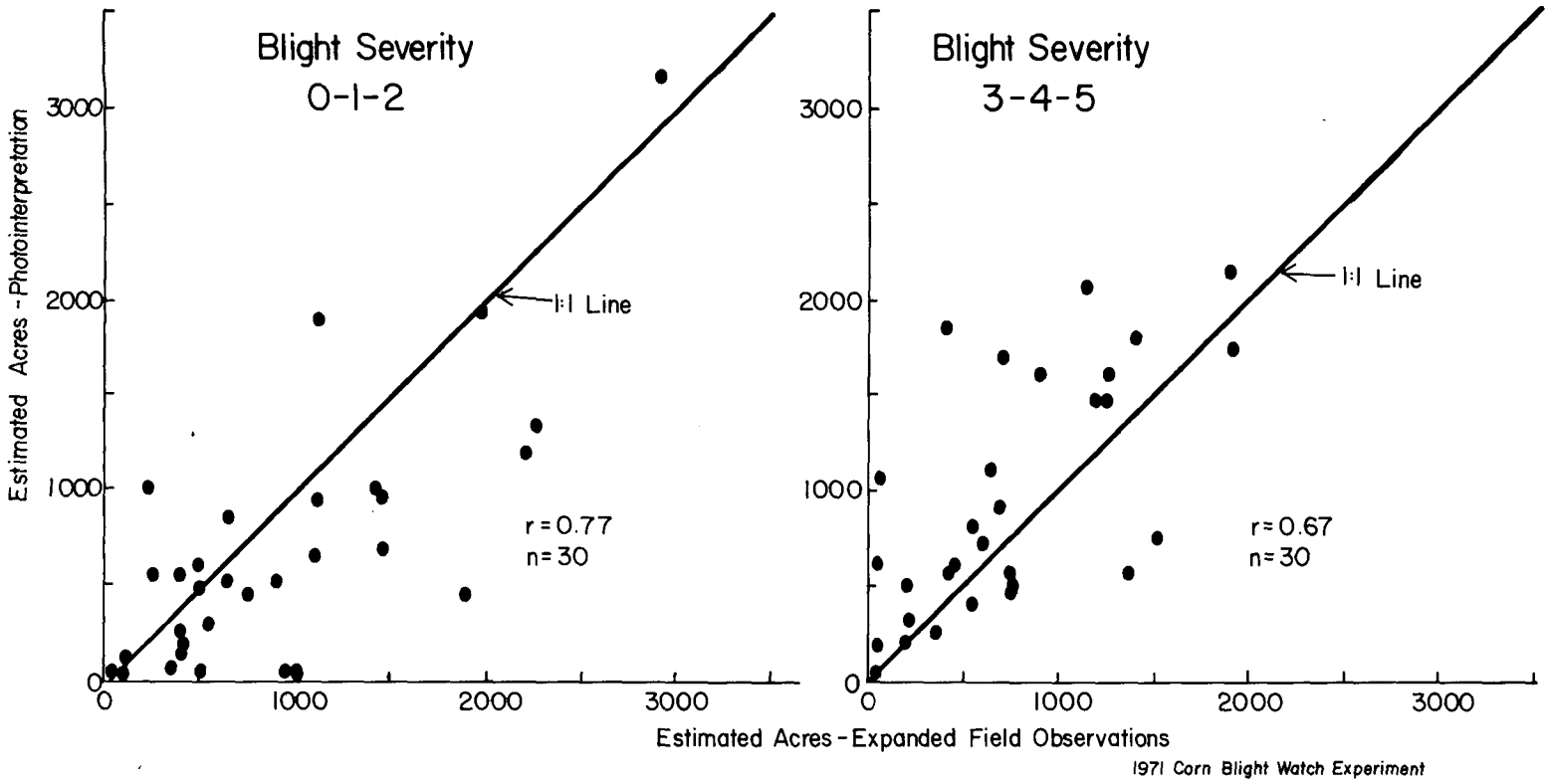


Figure 9. Correlation of field observation and photointerpretation estimates of acreages of healthy (blight levels 0-1-2) and blighted (3-4-5) corn in the intensive study area for the period beginning August 9, 1971.

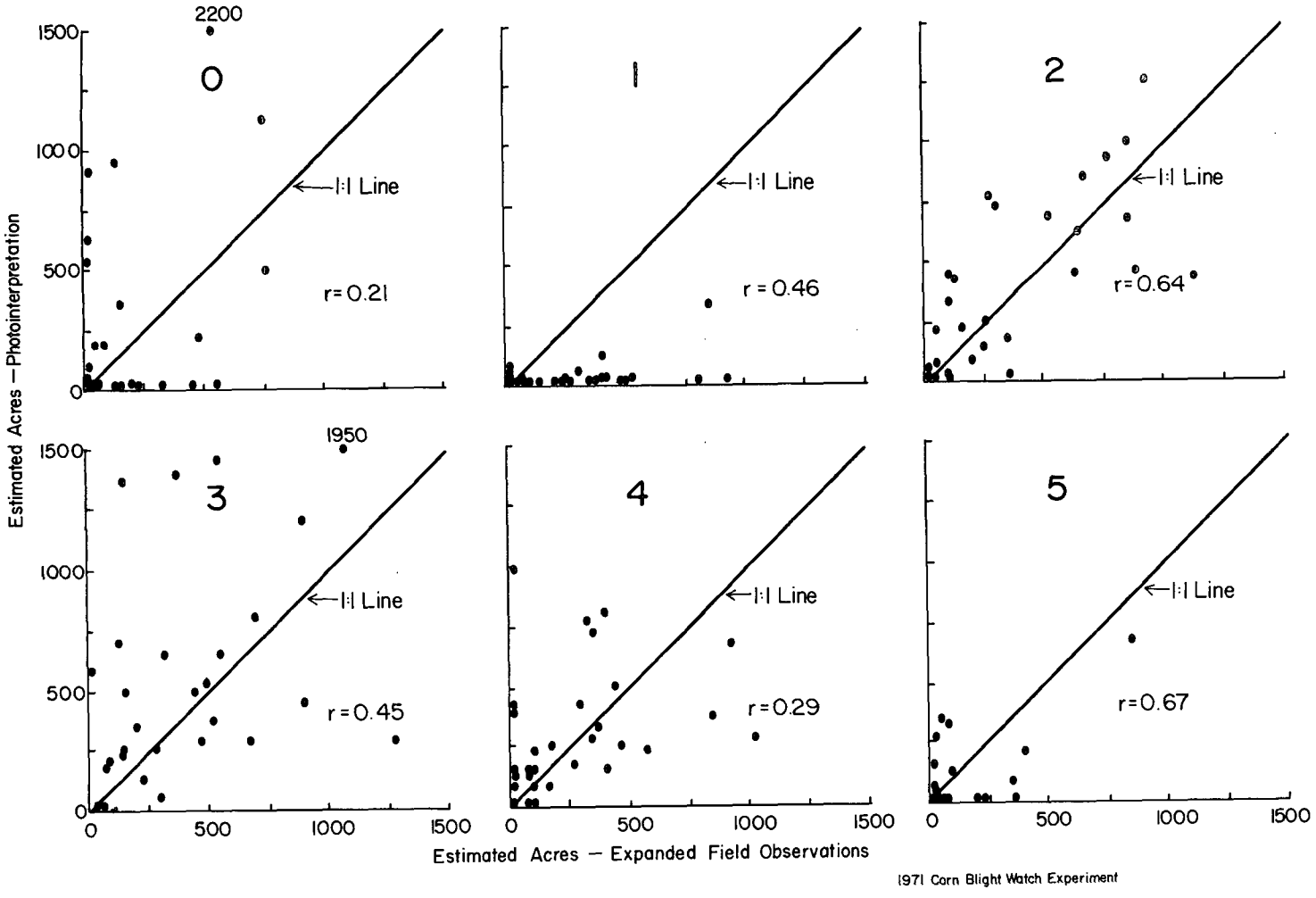
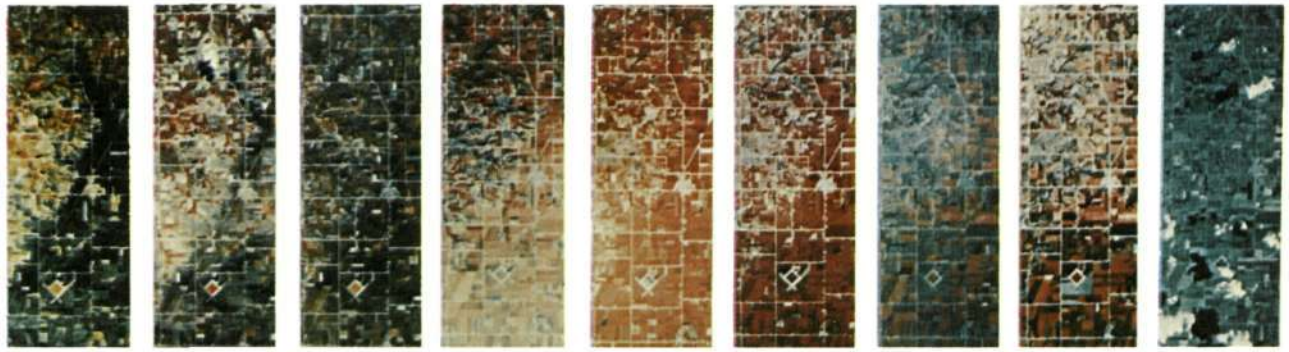


Figure 10. Correlation of field observation and photointerpretation estimates of acreages of individual blight classes in the intensive study area for the period beginning August 9, 1971.

Color Infrared Photographs of Two Segments Through the 1971 Growing Season



Segment 116 - Mahaska County, Iowa

Mission Period:	5/10-6/1	6/14-6/27	6/28-7/11	7/12-7/25	7/26-8/8	8/9-8/22	8/23-9/5	9/6-9/19	9/20-10/3

Segment 175 - Butler County, Nebraska

Figure 11. Color infrared photographs of segment 116 and 175 through the 1971 growing season.

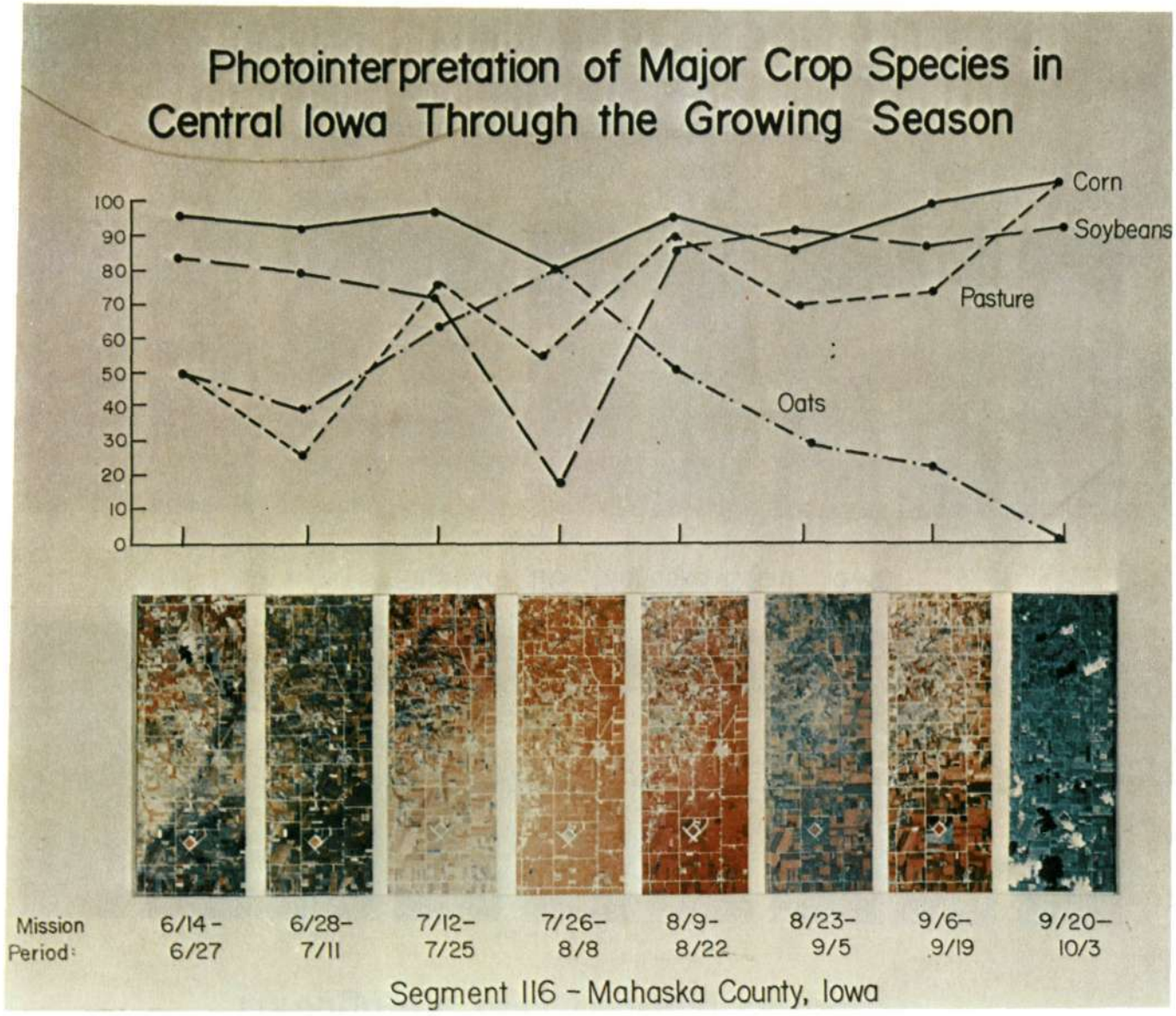


Figure 12. Identification by photointerpretation of major crop covers in Central Iowa through the 1971 growing season.

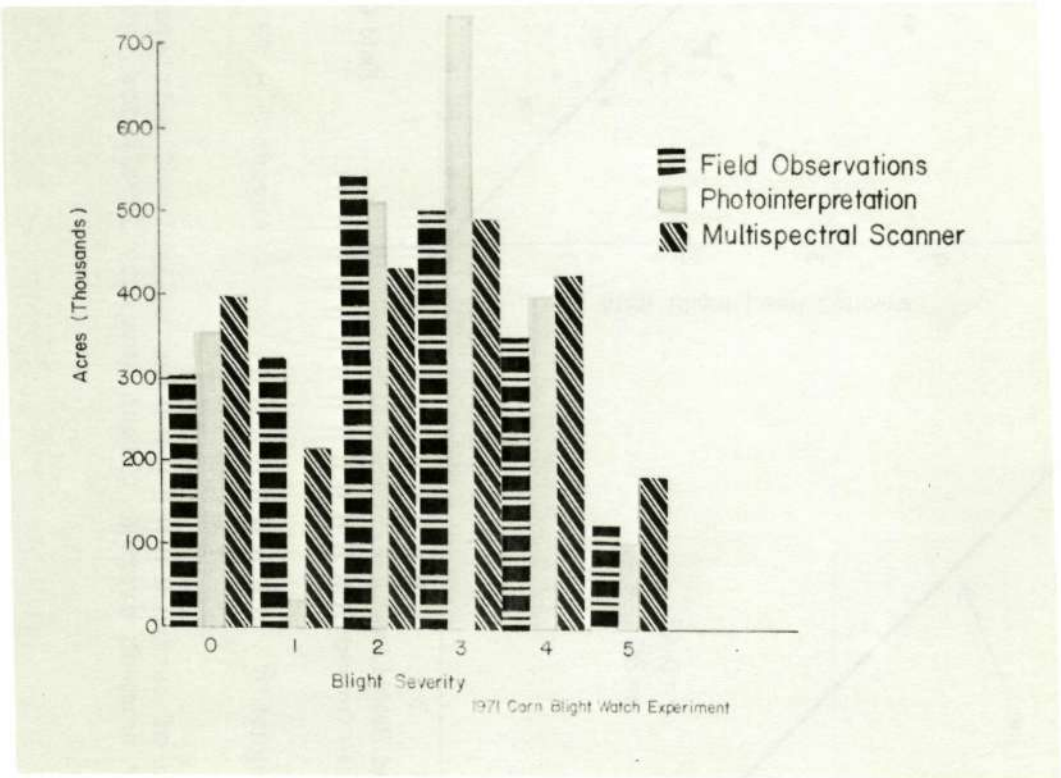
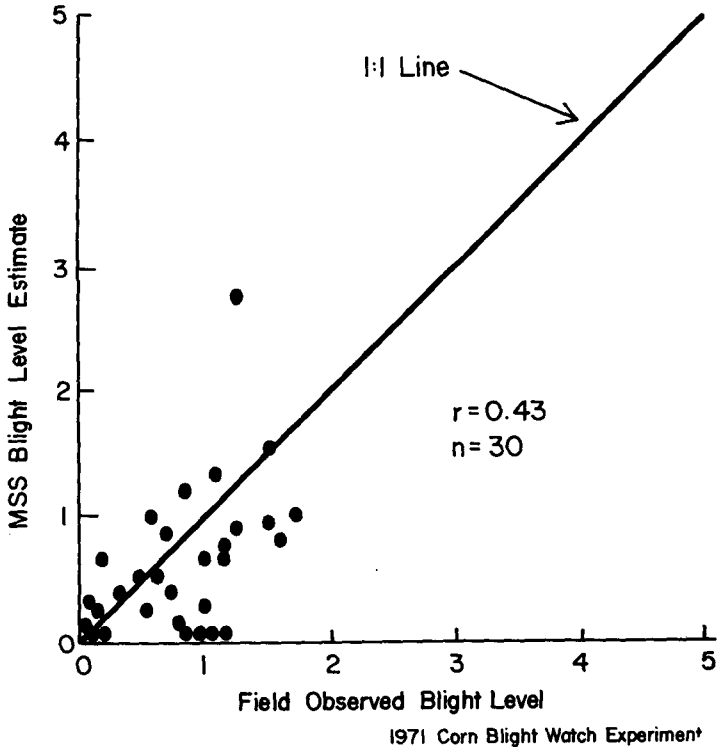
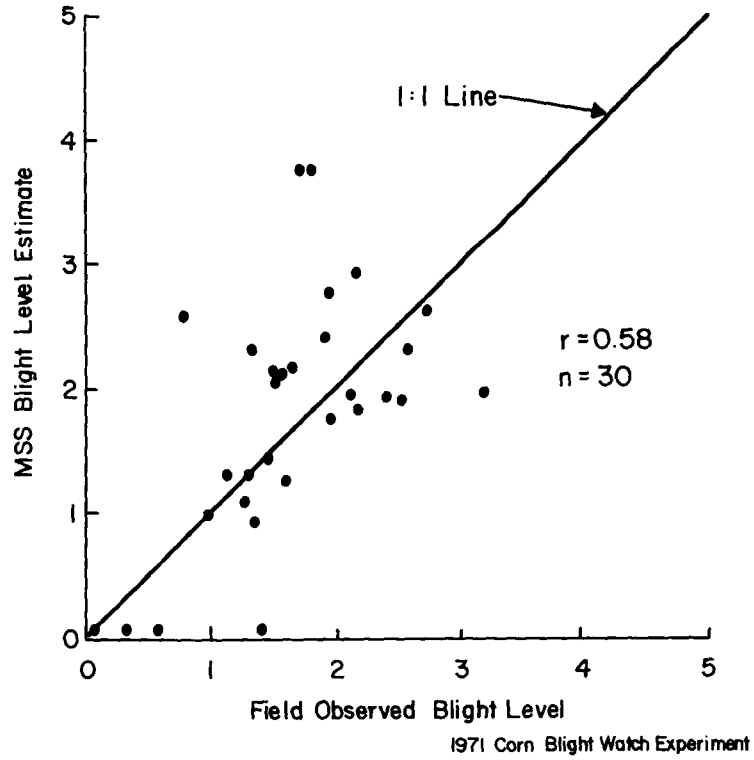


Figure 13. Comparison of field observation, photointerpretation and machine analysis estimates of corn acreage in individual blight classes for the mission period beginning August 23, 1971.

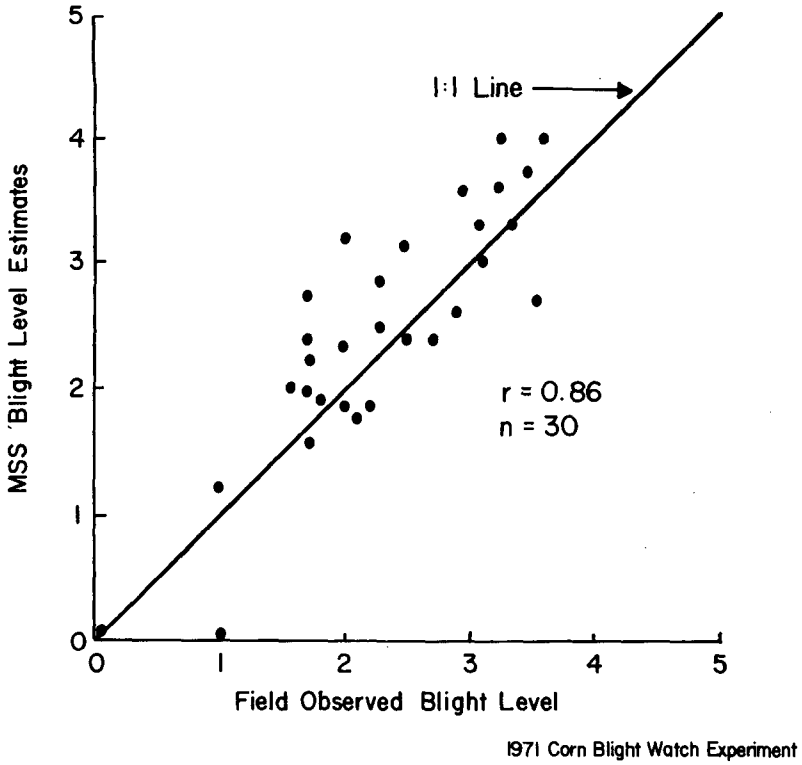


a. July 26 - August 8

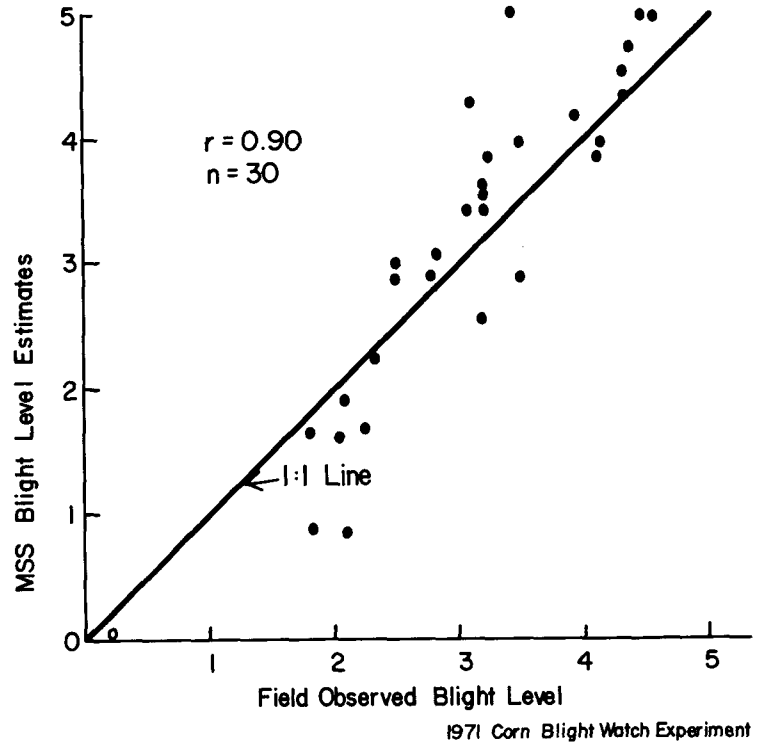


b. August 9 - 22

Figure 14. Correlation of estimates from machine analysis of multispectral scanner data and field observations of segment average blight severity levels for four successive mission periods.



c. August 23 - September 5



d. September 6 - 19

Figure 14. Concluded.

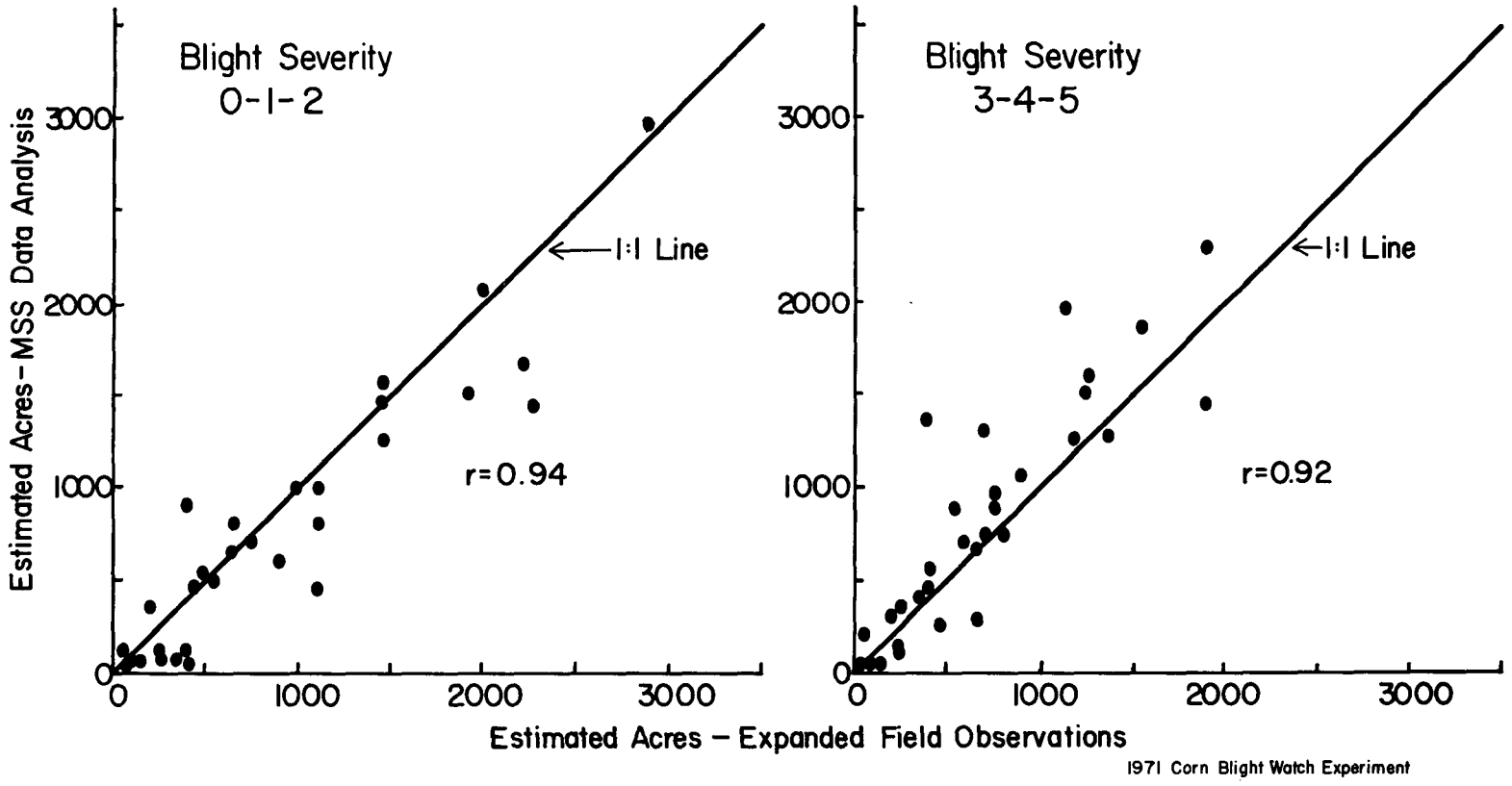


Figure 15. Correlation of estimates from multispectral scanner data and field observations of acreages of healthy (blight levels 0-1-2) and blighted (3-4-5) corn in the intensive study area for the period beginning August 9, 1971.

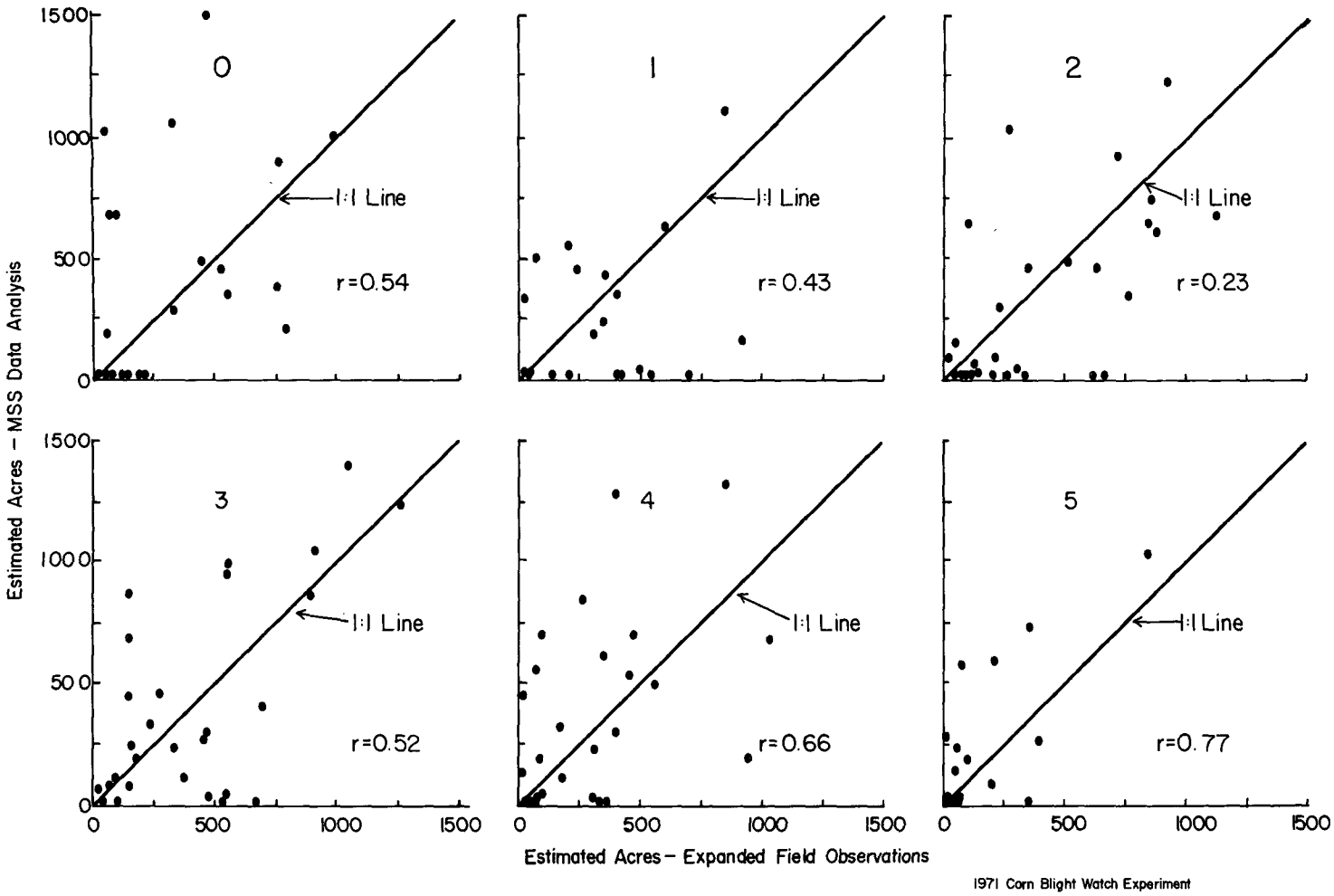


Figure 16. Correlation of estimates from multispectral scanner data and field observations of acreages in individual blight classes in the intensive study area for the period beginning August 9, 1971.

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