

REMOTE SENSING TO CHARACTERIZE STRESSES ON SOYBEANS IN FIELDS WITH HIGH-pH SOILS

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Recent studies unexpectedly revealed that losses of fall-applied anhydrous ammonia tended to increase with increase in soil pH. The greatest losses occurred on "calcareous soils", which have free carbonates and pH values in the range of 7.5 to 8.4. The studies also revealed that the calcareous soils occur in spatial patterns that often are much more complex than indicated on soil survey maps. Studies were initiated during the 2000 growing season to evaluate the possibility that aerial photographs of soybean crops would provide a simple and effective way to map calcareous areas within fields.

The rationale for the study was that it is well known that soybean crops are stressed by soils having pH values high enough to contain free carbonates. Effects of the stress include yellowing of leaves (chlorosis), reduced vegetative growth, and decreased yields of grain. We reasoned that the first two of these effects should be easily detected in aerial photographs, which have unique ability to characterize spatial patterns.

Observations made during the study indicated that we had stumbled on a new method for constructing detailed maps showing intensity of stress on soybean as a function of position within the field. The objective of this paper is to describe what we did and what we learned.

Methods

Many soybean fields in Greene and Boone counties were photographed from an airplane several times during July and August of 2000. Just before harvest, soil and plant samples were collected at numerous points within ten fields that showed clear spatial patterns in greenness of the soybean canopy throughout the summer. The sampling points were selected to capture the entire range of greenness shown in the photographs. Plant height and yields of grain were measured at each point.

Soil samples collected at each point were analyzed to quantify three different stresses that could be responsible for observed differences in plant height and yield.

1. Soil pH as measured in the laboratory during routine soil testing.
2. Soil carbonate content expressed as percentage calcium carbonate equivalent.
3. Number of soybean cyst nematode (SCN) eggs/100cc soil.

The importance of each stress was assessed by examining ability to explain differences in yields of grain within each field. To provide a simple index of plant response to all stresses within the field, yields at each point were expressed as a percentage of the highest yields obtained at any point sampled.

Results

Spatial patterns in color tended to remain relatively constant throughout the summer, and similar patterns remained even after the color of the plants changed from green to brown. The spatial patterns in color usually were caused more by the amounts of soil showing through the canopy than by the color of the plants. Especially when soybeans were planted in 30-inch rows, small differences in color provided a sensitive and reliable way to detect spatial patterns in plant height. Plant height correlated well with grain yields where only a single variety of soybean was considered. The poorest yielding portions of the field often yielded less than 10% of the highest yielding portions of the field.

Soil pH and carbonate content emerged as the most important factors affecting grain yields in most fields (Fig 1). The relative importance of these two factors depended on the field considered. Soil pH usually was most important in fields that had relatively few samples with high carbonates. Soil carbonate content usually was most important in fields where a high range in carbonate content was found. Soil pH and carbonate content are not totally independent factors because soils with carbonates have high pH values (7 to 8.4).

Soil pH and carbonate were combined into a single index of stress, which we call an “alkalinity stress index”. The index was derived empirically and is calculated by multiplying the percentage calcium carbonate equivalent by 0.22 and adding the result to the soil pH. This index explained more than half of the variability in yields observed at 7 of the 10 sites.

Relationships between yields and number of SCN eggs were not statistically significant at 8 of the 10 sites sampled. At the two sites where numbers of SCN eggs were highly correlated with yields, numbers of eggs were highly correlated with pH, which also was highly correlated with yields.

Three of the 10 sites showed great variability in yields, but the yields showed no significant relationships with any of the soil characteristics measured. This finding suggested the existence of at least one important factor that was not considered.

Follow-up studies during the 2001 cropping season identified compaction in calcareous soils as an additional important factor. Within calcareous areas, soybean plants growing in wheel tracks grew much better than nearby plants growing without wheel tracks. Possible explanations for this effect are being explored. It is clear, however, that variability in compaction within calcareous soils causes variability in yields that makes it easy to underestimate the effects of carbonates.

Conclusions

Carbonate content needs to be recognized as an important and measurable factor influencing amounts of stress on soybean.

Remote sensing of soybean canopies and using the resulting images to guide soil sampling is an effective way to map carbonate content of soils.

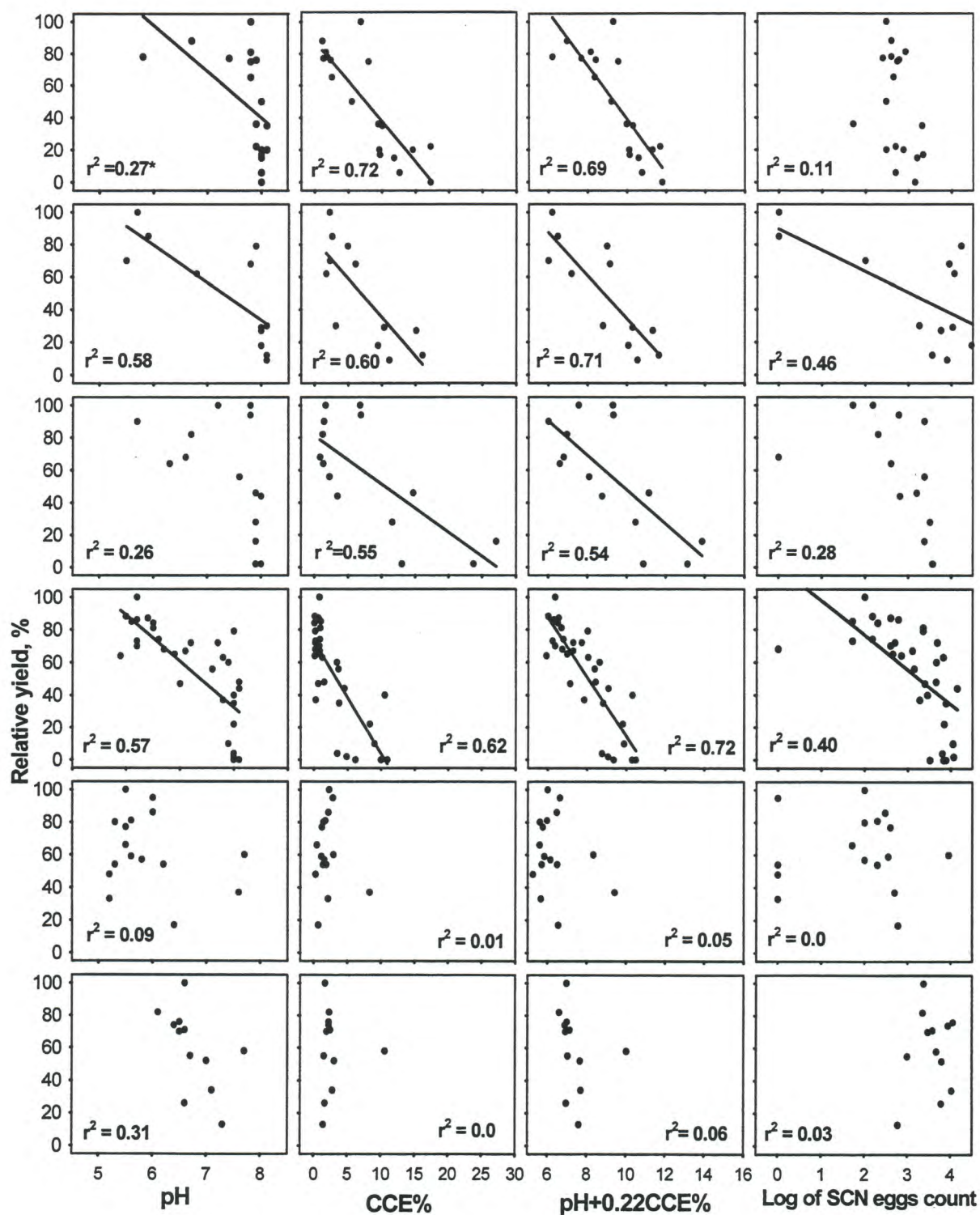


Figure 1. Examples of observed relationships between relative yield and stress factors from 6 sites. Data from each site is presented as a horizontal series of graphs.