AIS INVESTIGATION OF AGRICULTURAL MONOCULTURES

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ABSTRACT

Airborne Imaging Spectrometer (AIS) data were acquired over an agricultural area in eastern San Joaquin County, California in July, 1984. Cover-type information was subsequently collected for all fields along this flight line. The lack of detailed ground data on individual fields, however, limited AIS data analysis to a qualitative comparison of the spectral reflectance curves for a total of nine cover types. Based on this analysis, it appears that cover types with a positive slope in the 1550-1700 nm region have a higher spectral response in the 1200-1300 nm region compared to those cover types with a negative slope in the 1550-1700 nm region. Within cover type, spectral variability was also found to be greater than that between cover types. Given the lack of additional field data, the reason for these differences is a matter of speculation.

INTRODUCTION

For several years, the NASA/Ames Research Center (NASA/ARC) has been involved in the application of remote sensing data to agricultural research in California. During the 1983 growing season, researchers at NASA/ARC and the University of California, Berkeley cooperated in the collection of ground data including: crop type, growth stage, percent ground cover, canopy height, surface moisture, weediness, row direction/width and irrigation method on over 200 fields in eastern San Joaquin County, California. The collection of these data was coordinated with the acquisition of Daedalus Thematic Mapper Simulator (TMS) data on seven dates throughout the growing season. These data were used both to evaluate Landsat Thematic Mapper (TM) resolution data for crop identification and mapping and to understand the relationship between changes in surface/crop conditions and spectral reflectivity.

One of the findings of this research was that at the level of TM data resolution, considerable spectral crop confusion results from the relationship between crop canopy structure, percent ground cover and soil moisture content. In an effort to address this issue, Airborne Imaging Spectrometer data were requested for a portion of the San Joaquin County study area. The intent was to coordinate the collection of ground data with the acquisition of the AIS data. Ground data collection was to include those variables monitored in 1983, as well as plant tissue for laboratory spectral and chemical analysis. In actuality, it proved impossible to coordinate these activities and only cover type information was obtained several weeks after the AIS flight.

DATA ACQUISITION AND ANALYSIS

The AIS, mounted on the NASA C-130 aircraft, acquired data along Jack Tone Road in eastern San Joaquin County, California on July 31, 1984. These data cover the wavelengths between 1155 and 2336 nanometers (nm) at a sampling interval of approximately 9.3 nm. Ground resolution of the data is approximately ten meters with a 32 pixel swath width.

The 35-mm black and white photographs, acquired at the same time as the AIS data, were used to locate the flight line, and served as the base on which field cover-type data were recorded. The field reconnaissance took place in late August, 1984. Due to this delay, some of the fields identified as bare soil may have supported a crop at the time of the AIS overflight. Whenever possible, these fields were labeled as to previous cover type. If there was any question about cover type at the time of the AIS overflight, the field was not included in the subsequent analysis.

Analysis of the AIS data was performed on a VAX 11/780 using IDIMS image processing software and additional programs developed specifically for AIS analysis. All AIS channels were registered for analysis purposes. No other preprocessing (i.e., atmospheric correction) was, however, attempted.

For each of the nine cover types identified along Jack Tone Road, one or more two-by-two pixel areas were extracted and labeled. The spectral values for all 128 channels were then plotted. A preliminary analysis of the different cover types was undertaken to determine the maximum reflectance value against which other cover types could be scaled. Of the nine cover types identified, stubble had the highest reflectance values and, therefore, became the reference cover. Other cover types included: corn, alfalfa, beans, sugar beets, tomatoes, peppers, vineyards, and bare soil. An adobe clay soil was found throughout the study area.

DISCUSSION

Since the only ground data available to this study was cover type, discussion of results is both preliminary and speculative. Other researchers may opt to interpret these data differently based on a greater knowledge of vegetation response in the 1155-2336 nm region.

Figures 1 and 2, which show reflectance curves for beans and sugar beets, respectively, are typical of the general patterns observed for most other cover types. The positive slope in the 1550-1700 nm region for beans (.3) and sugar beets (.2) corresponds with higher reflectance values in the 1200-1300 nm region. The negative slope in the 1550-1700 nm region observed in beans (.1) and sugar beets (.1) corresponds with lower reflectance values in the 1200-1300 nm region.

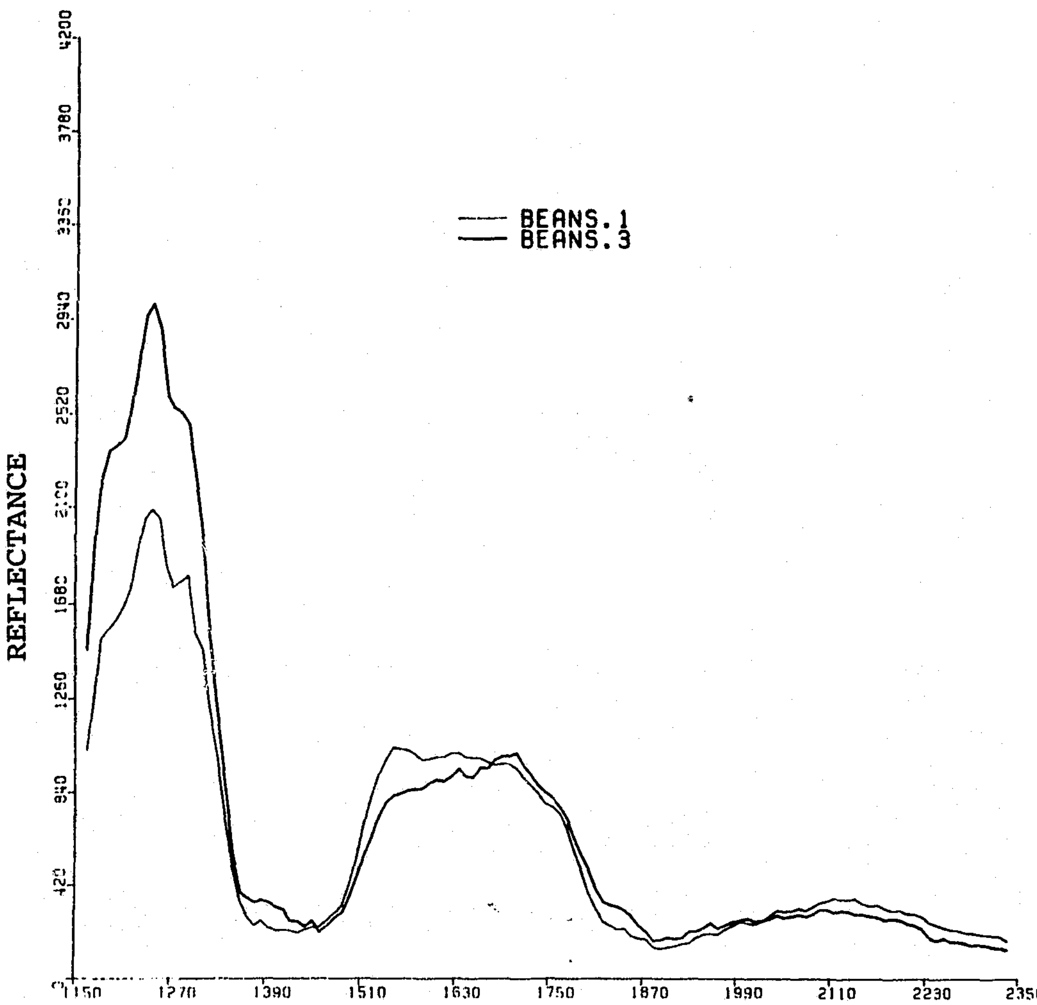

Figure 1. AIS spectra for two bean samples. The positive slope in the 1550-1700 nm region is associated with a higher response in the 1200-1300 nm region. The negative slope in the 1550-1700 nm region is associated with a lower response in the 1200-1300 nm region. Unlike sugar beets, beans are cultivated during a definite season and, as such, all fields should be about the same age. The difference in slope is, therefore, not easily explained on the basis of growth stage or age alone.

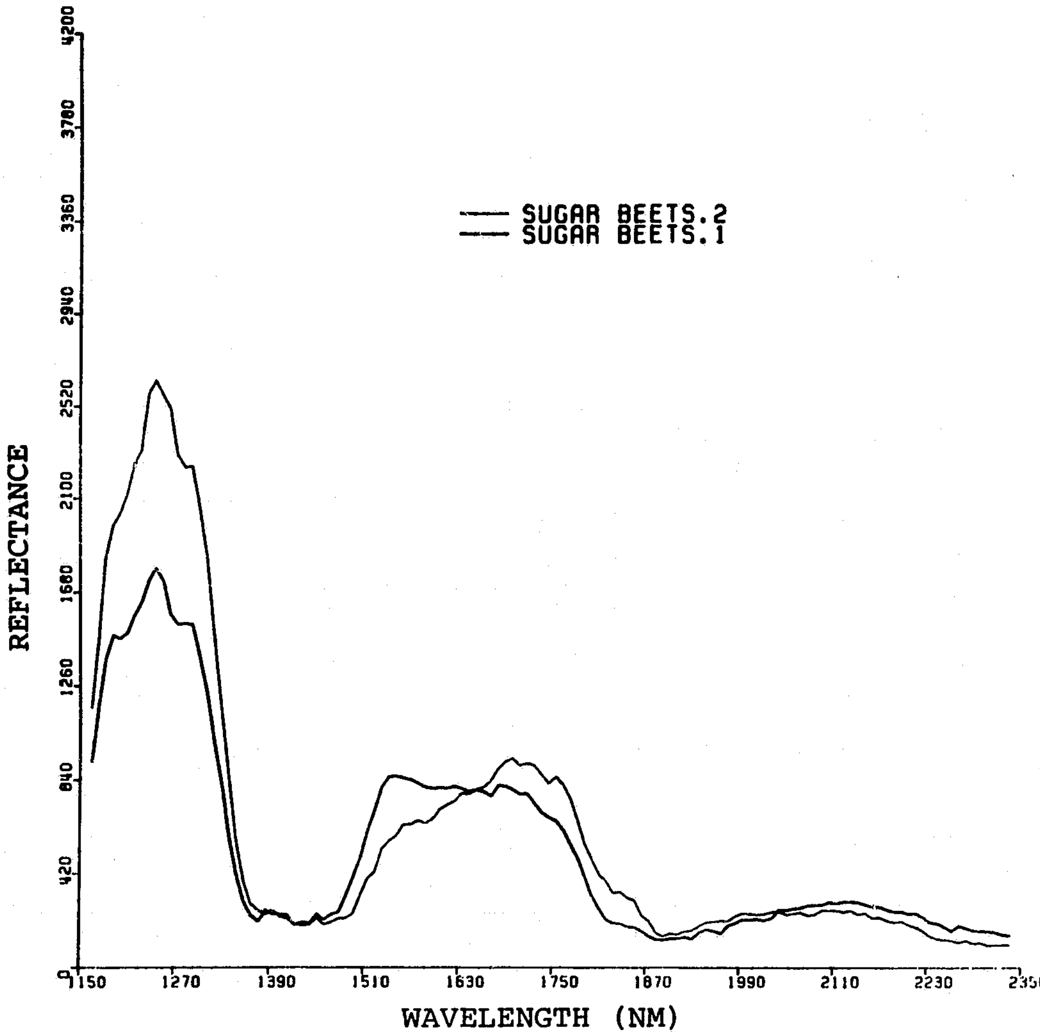

Figure 2. AIS spectra for two sugar beet samples. The positive and negative slopes of the reflectance curves in the 1550-1700 nm region are clearly evident as was the case for beans (Figure 1). Since sugar beets are cultivated year-round, it is nearly impossible to determine the growth stage for the individual fields.

The negative slopes for beans (.1) and sugar beets (.1) are similar to the curves shown in Figure 3. All bare soil plots exhibited this same general shape. The similarity between these curves suggests that either the soil background is influencing the reflectance (lower percent ground cover), field conditions are drier, or the plants are undergoing senescence.

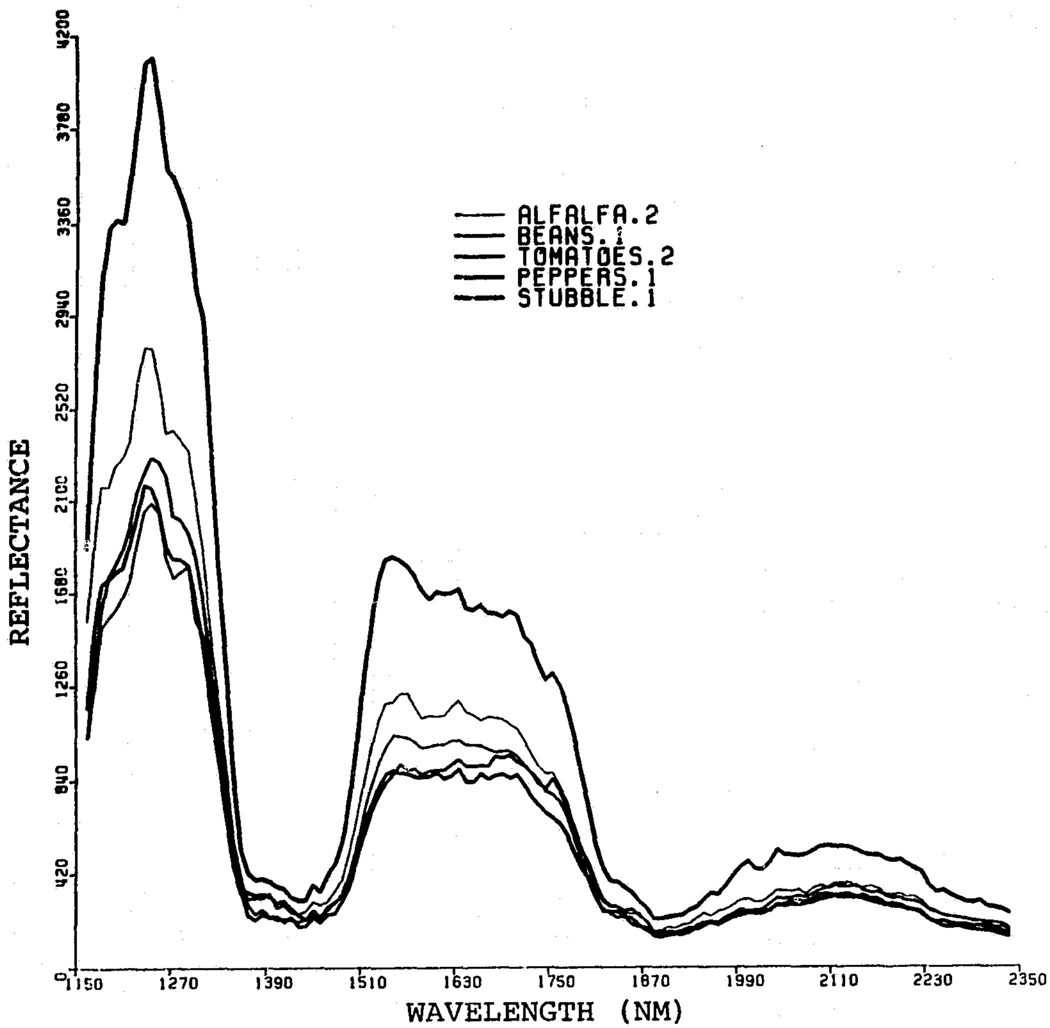

Figure 3. AIS spectra for alfalfa, beans, peppers, tomatoes, and stubble. All these crops have a negative slope in the 1550-1700 nm region. Although the shape of the reflectance curves are similar, the values are different. If not for the similarity of the curves in Figure 4, it would seem likely that the difference was simply a matter of crop-type differences.

Since no ground data were available for well-watered fields, with complete canopy cover, it is difficult to substantiate the idea that the positive slope in the 1550-1700 nm region corresponds to such conditions. This view is supported, however, in part, by the higher reflectance in the 1200-1300 nm region which is characteristic of healthy active-growing crops. Figure 4 shows four fields which follow this general pattern. All have positive slopes in the 1550-1700 nm region and relatively high and consistent values in the 1200-1300 nm region. Not only are the shapes of these curves similar, but the reflectance values along them are fairly similar. This is surprising, given the considerable differences between the four crops in terms of size, canopy shape, and growth characteristics.

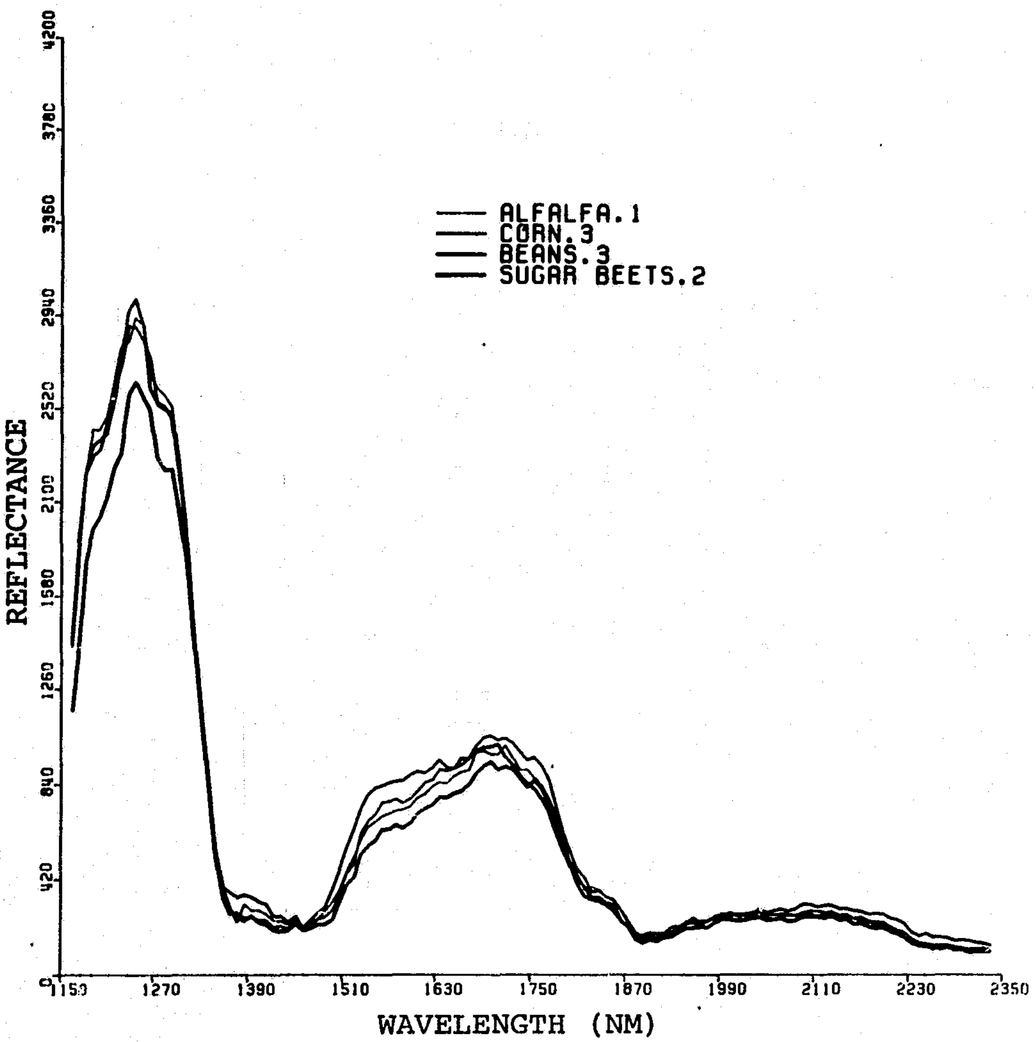

Figure 4. AIS spectra of alfalfa, corn, beans, and sugar beets. All these crops are examples of the positive slope in the 1550-1700 nm region. Although the reflectance curves are similar, the crops are different in terms of structure, canopy, and growth characteristics.

The negative phase in the 1550-1700 nm region is shown for five cover types in Figure 3. Although the curves are similar in terms of overall shape, they exhibit considerable variability in reflectance values. Given the similarity of the curves in Figure 4, this difference in reflectivity can not be explained solely on the basis of different cover type. It may, however, be a function of changes in the plant as it becomes subject to moisture stress or reaches maturity. In either event, reflectivity should change throughout the spectrum. As moisture content decreases, other leaf components will have a greater influence on reflectivity.

CONCLUSIONS

Based on a preliminary, qualitative analysis of AIS data acquired over an agricultural area in eastern San Joaquin County, some basic differences between crop spectral profiles have been identified in the 1155-2336 nm region. A positive slope in the 1550-1700 nm region corresponds with higher reflectance values in the 1200-1300 nm region. This does not appear to be related to crop type. A negative slope in the 1550-1700 nm region corresponds with lower reflectance values in the 1200-1300 nm region. This also does not appear to be related to crop type.

The positive and negative slopes in the 1550-1700 nm region seem to be related to plant moisture content, or differences in leaf chemistry growth stage. All crops with the positive slope had similar reflectance curves, regardless of considerable differences in crop structure and growth characteristics. This suggests that whatever factor is the dominant influence on reflectance in the 1155-1336 nm region is common to all of the crops studied.

Crops with a negative slope in the 1550-1700 nm region, although exhibiting similar overall reflectance curves, show considerable differences in terms of absolute reflectance values. These differences may be a result of changes in plant structure, moisture content, mineral uptake and, hence, leaf chemistry as the plant matures and approaches senescence.

In order to answer the questions raised by these spectral curves, one needs to collect considerable and detailed field and laboratory data regarding profiles of the plants of interest over time. Agricultural environments are excellent areas in which to undertake these studies since conditions are uniform over a broad region where they can be easily measured, and since the entire sequence of plant development stages occur in a relatively short period of time.