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ROLE OF MULTISPECTRAL DATA IN ASSESSING CROP MANAGEMENT AND CROP YIELD

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I. ABSTRACT

Airborne multispectral data, in conjunction with the groundtruth information is utilized to identify the rice crop management levels and for assessing the agricultural potentials of a region. Variations in the amount of green biomass, under different management levels resulted in significant differences in the crop spectral reflectance responses, to identify different crop management levels. The spectral reflectance ratio of red and infrared regions increased gradually with the crop growth and decreased with the progress of maturity, in all the management levels. The average crop spectral response suggested that high spectral response was related to good management and higher crop yield and low spectral response was to poor management level and low crop yield. The technique of spectral logging may be one possibility of monitoring the Agricultural potentials of a region.

II. INTRODUCTION

Crop growth is a physiological phenomenon, which brings out morphological manifestations as a result of interaction with the environment, expressing in different stages during the lifecycle of the plant. It is highly influenced by the environmental factors like rainfall,solar radiation, soil type, relative humidity, irrigation, temperature etc. and the level of crop management. Crop management includes cropping pattern, choice of variety, time of planting, water, fertilizer management, pest control and other agronomic measures and is profoundly influenced by socioeconomic conditions of the farmer. Proper assessment of crop growth and management will provide information in advance about the probable yield that can be obtained after the harvest of the crop, which will be helpful for planning purposes.

In recent years several scientists have demonstrated the potential use of remotely sensed data in the identification of crop species, area estimation, and prediction crop yields. Multispectral scanner data has been used for identification of agricultural crops.[2,3,4,16,18,21] Satellite remote sensing has been reported to be successful for agricultural resource inventory,[20] and to identify and estimate crop acerage upto 90 per cent accuracy level.[5,6] Utility of satellite data for monitoring of wheat production was discussed by Hammond.[8] Various methods were proposed to predict winter wheat yield using regression models,[19] stress degree concept,[11,12,13] Landsat derived estimates of Leaf area index(LAI) data coupled with evapotransporation models,[9,24] and crop senescence rates.[14] Satellite data, in conjunction with mateorological data and historical data had been used for global monitoring of wheat production.

Red and Photographic infrared spectral data were found to have high correlation with the active green leaf canopies of corn, sovbean, alfaalfa and other crops.[7,10,15,22] Ration of Infrared/Red radiance was the spectral variable, most highly correlated with the green LAI and green leaf biomass.[1,23] Spectral data were used to estimate yield related variable such as LAI, because grain yield is usually highly correlated to LAI.[7] As mentioned above, the green leaf area is one of the major variable in crop production and continuous monitoring of this parameter during the crop season may provide information about the crop growth development and resultant spectral variations. The variations in the crop growth as affected by the differences in the management, therefore, can also be clearly viewed through the spectral responses of the crop canopies. Further, scientists had used different techniques like crop logging, and crop growth monitoring, to assess the interactive effects of environment and their relation to crop production. The spectral data of the crop can be used in the same way as the crop logging technique, for assessing crop production.

In this experiment an attempt has been made to utilise the remotely sensed multispectral data, in conjunction with the groundtruth data, to identify the rice crop management levels and for assessing the agricultural potentials of a region.

III. MATERIALS & METHODS

A. SCENE DESCRIPTION

The experiment was conducted in four test sites of southern part of India during one of the major crop growing season. (February to June, 1979). Vast irrigation potential, suitability of soil and climatic conditions encourage farmers of this region to grow wide varities of crops. Rice and Sugarcane are the major crops grown in this area on an average field size of 2-3 acres. The other crops grown scatteredly in small fields are Fingure millet, Groundnut and Mulberry. Thus, at a given time of theyear, several crop species in various stages, and proportions can be seen exhibiting a highly heterogenous nature of agriculture.

B. DATA ACQUISITION

1. Spectral information: An eleven channel modular multispectral scanner (Bendix) was used for obtaining airborne multispectral data. The spectral data was recorded on a high density digital tape (HDDT) on board from an altitude of 1000 meters above the ground level with an instantaneous field of view of 2.5 milli radians and a ground resolution of 2.5 meters during the entire crop growing season starting from February to June, 1979. The spectral regions covered by the multispectral scanner are presented in table 1.

2. Groundtruth collection: The airborne multispectral data was simulatneously supported by groundtruth investigations, which included visual information about crop species, crop canopy coverage, color, stage of the crop, plant height and other data related to crop condition.

Grain yield data was obtained over 30 fields selected from the four test sites. Grain yield data were collected from 6 randomly selected plots (1 SQ.M.) in each rice field of one acre. From these sampling units, all the panicles were harvested, hand thrashed and sterile grains were seperated. Moisture content of the grains was determined and the final grain yield was adjusted to 14 per cent moisture and reported as metric tonnes per hectare. The grain yield was categorised into three groups ie. high ($<$5t /ha), medium, and low ($>$3t/ha), based on the groundtruth information.

3. Extraction of spectral information and data processing: The multispectral data obtained on HDDT was converted into computer compatable tape format (CCT) with the aid of Multispectral Data Analysis System (M-DAS). For analysis and extraction of spectral data the CCT containing spectral information was displayed on colour moving window (TV) of M-DAS and the area for spectral data extraction and training samples for training the computer were identified, based on groundtruth information. Spectral ratios of red (0.66μ to 0.70μ) and infrared (0.77μ to 0.86μ) regions were obtained.

IV. RESULTS AND DISCUSSIONS

With the constant physiological changes in the crop growth, the crop stages, the amount of biomass, and the associated per cent vegetative cover per unit area vary, resulting in differences in the spectral responses of the crop canopies, particularly in the red and infrared regions of the electromagnetic spectrum. Several workers have demonstrated that the red and photographic infrared data are highly correlated with photosynthetically active green biomass of crop cover types.[1,7,15,22] The spectral variations and the ratio of red and infrared bands are useful in identifying the crop species and its growth stage in conjunction with the groundtruth.[4]

From the spectral data presented in Figure (1) it is clearly possible to identify different management levels exhibited through the variations in the amount of green biomass present and management effect on the green biomass. Further, in all the management levels, the spectral reflectance ratio increased gradually as the crop attained its peack of vegetative growth, and then decreased as the crop matured. Tucker et al [23] had reported similar observations in the winter wheat, using the hand held radiometer.

Based on the ground truth data, the spectral responses of the rice crop under different management levels, with similar trends, were categorized into three possible groups (Figure 2). Further, from the spectral information obtained at various crop growth stages, from planting to maturity of the crop, average spectral reflectance values were computed and plotted against the wavelength (Figure 3). The average spectral response of various management levels were considered in this experiment with an assumption that the average response would take care of the interaction between environment and crop management during the crop growing season. The spectral responses were related with the crop production level, in consultation with the field observations.

A close study of the data presented in Figures two and three will reveal that it is clearly possible to differentiate and identify the marked differences in the three management levels in all the sample areas except in the test site 4, where the differences between the management levels were rather marginal. This may be due to uniform management of the crop. Data in Figure one also substantiate this observation. The spectral responses presented in Figures two and three also suggest that high spectral response was related to good management and higher crop yield (<5t/ha) and low spectral response to poor management level and lower crop yield (>3t/ha).

From the above, it is be infered that the multispectral data can be successfully utilized for identification of variations in the crop management levels, resulted from variations in crop growth, which can serve as an important input in assessing the average crop yield performance of a region.

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Table 1. Spectral regions of eleven channel Multispectral Scanner

Visible Channel (Band)	Wavelength (μm)	
	Centre	Band width
1.	0.410	0.060
2.	0.465	0.050
3.	0.515	0.050
4.	0.560	0.040
5.	0.600	0.040
6.	0.640	0.040
7.	0.680	0.040
8.	0.720	0.040
9.	0.815	0.090
10.	1.015	0.090
Thermal Channel		
11.	11.000	2.500

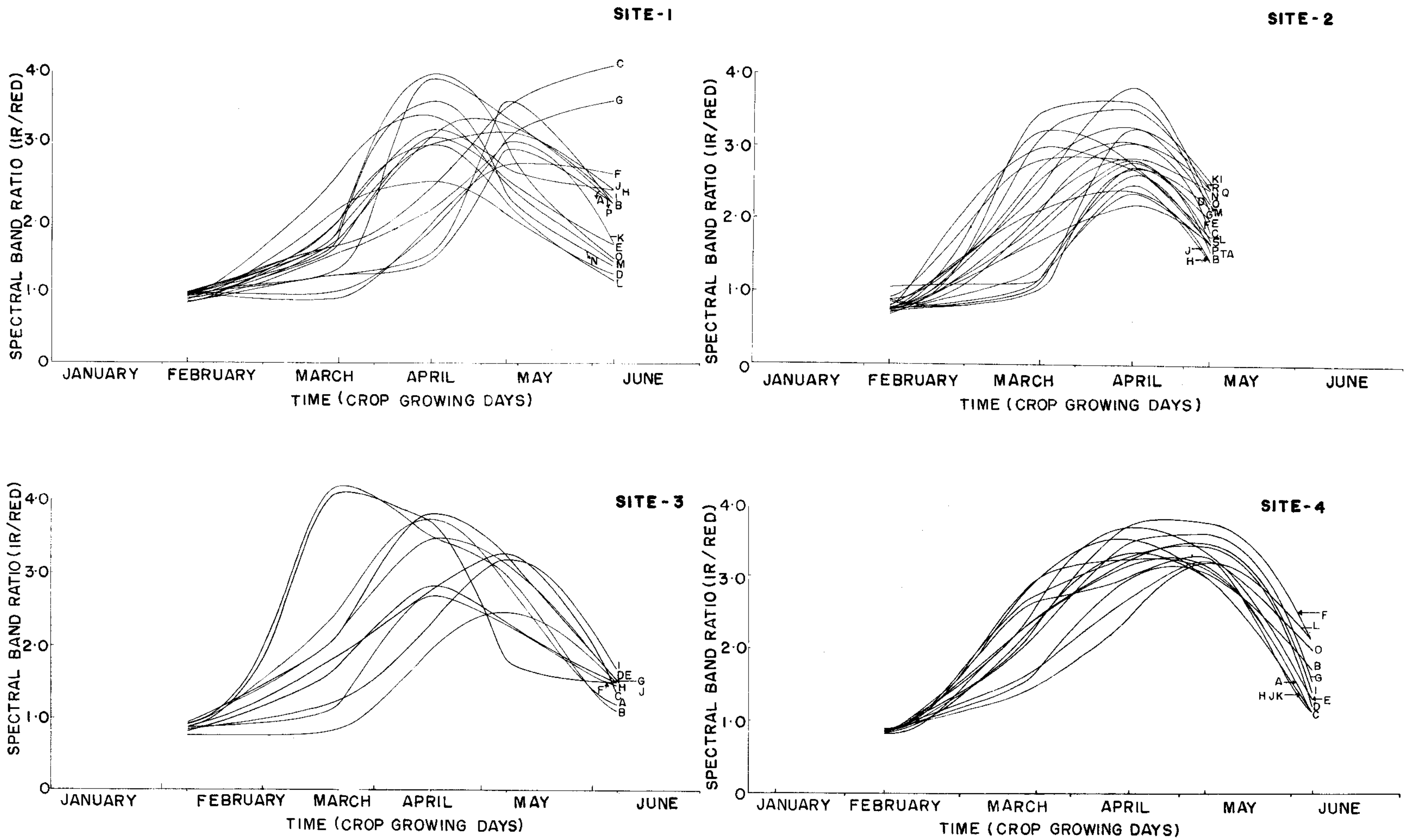

Fig. 1 SPECTRAL BAND RATIO AS INFLUENCED BY RICE CROP GROWTH WITH TIME SHOWING VARIATION IN CROP GROWTH PATTERN

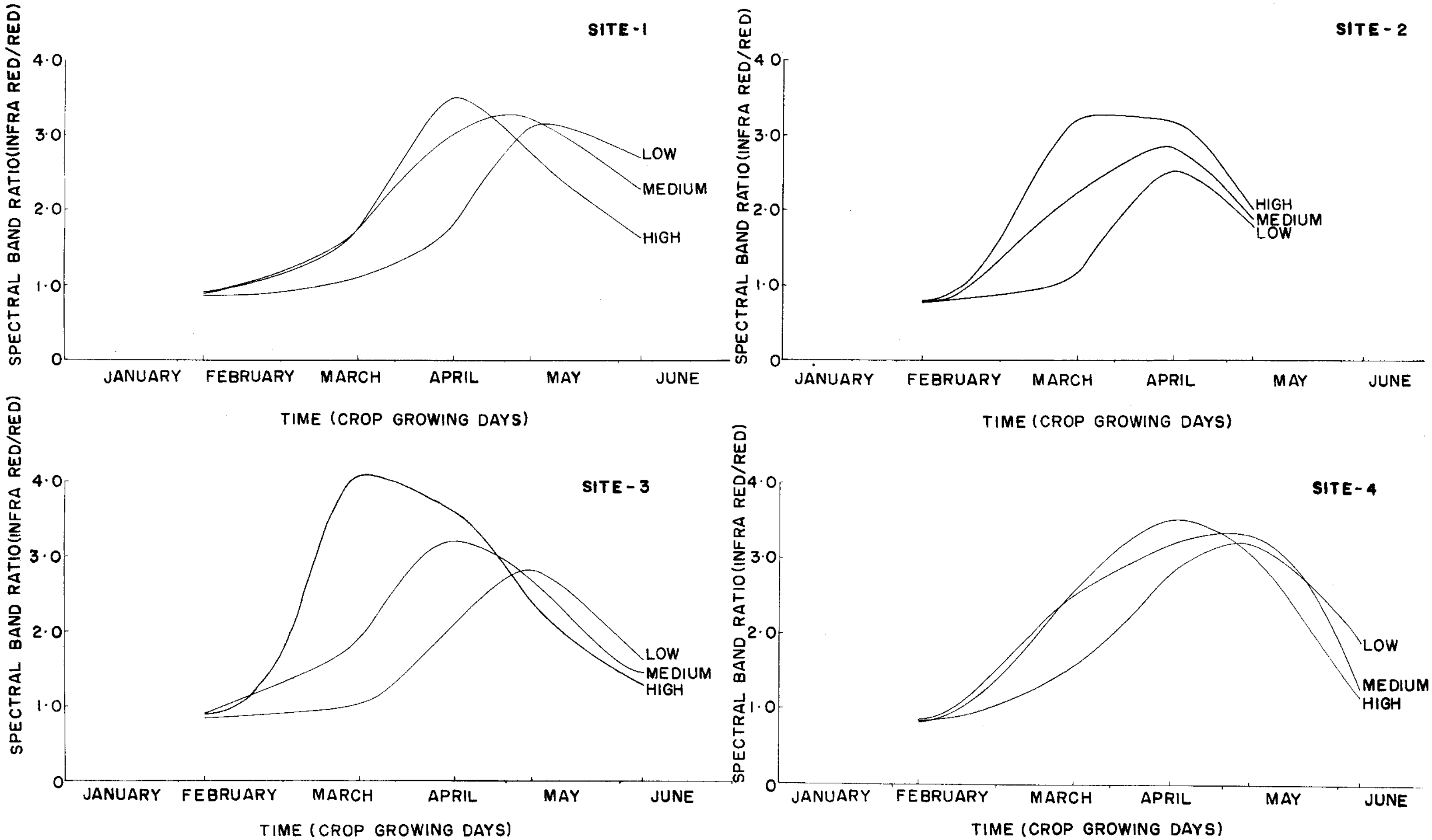

Fig. 2 SPECTRAL BAND RATIO AS INFLUENCED BY RICE CROP GROWTH WITH TIME AND ITS RELATIONSHIP WITH CROP YIELD

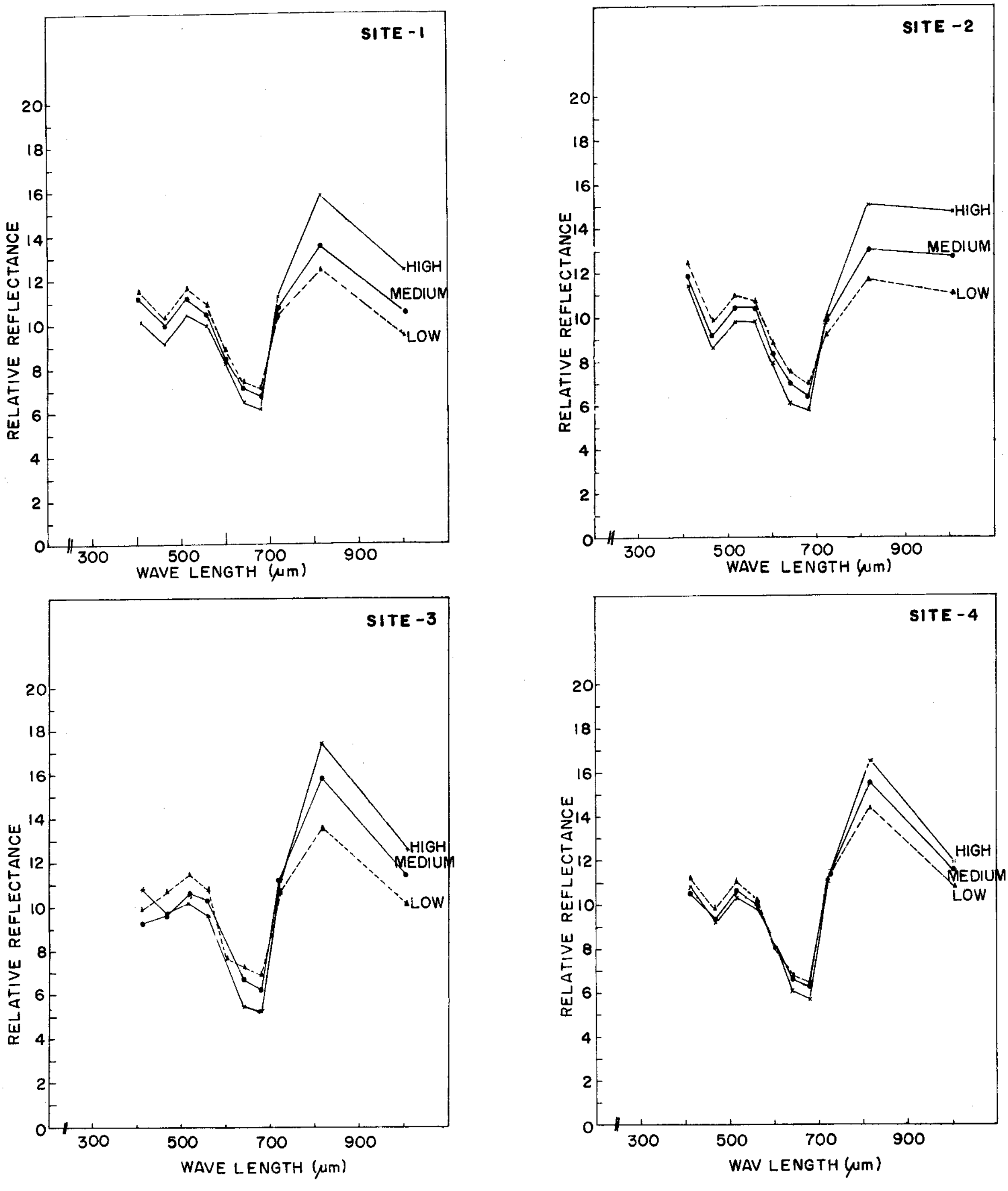

Fig. 3 AVERAGE SPECTRAL RESPONSE OBTAINED DURING RICE CROPPING SEASON INDICATING DIFFERENCES IN MANAGEMENT LEVELES AT FOUR TEST SITES

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