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Disease stress detection and varietal discriminability in *kharif* groundnut (*Arachis hypogaea L.*) through ground based spectral data

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ABSTRACT

The paper discusses results of a field experiment on *kharif* groundnut carried out to asses the varietal discriminabilty and disease stress along with biometric parameters-spectral and disease-spectral relationship using high resolution narrow band radiometer. The results indicate that spectral bands of 6 to 11 were the best for disease stress detection as well as for varietal discrimination. The refletances in spectral bands of R2 and R5 are more useful in estimating biometric parameters and disease. The reflectances in spectral band combinations of 3 and 4, 5 and 4 could be used to estimate yield.

Key Words : Groundnut, Spectral signatures, Disease, Varietal discrimination

India stands first both in acreage and production of groundnut (*Arachis hypogaea L.*) in the world. Among the states in India, Gujarat occupies first position in groundnut acreage and production. Remote sensing (RS) technology has been extensively used for forecasting crop production for major crops under normal weather condition in India (Anonymous, 1990; Navalgund *et al.*, 1990; Pokharna *et al.*, 1991). However, for yield estimation in rainfed situation agro-meteorological models prove to be very useful (Ray *et al.*, 1994). Pokharna *et al.* (1994) have studied the possibility of oil seeds production estimation at district level for Gujarat for the year 1992-93. This crop is prone to leaf spot disease. Therefore, it is essential to estimate the disease stress along with groundnut production using RS technique in order to interpret the satellite data.

In this context the present study was carried out to evaluate disease intensity using high resolution narrow band radiometer for making possible improvement in sensors of future satellites in collaboration with Space Applications Centre (SAC), Ahmedabad. To study the spectral signatures of groundnut and also to evaluate the feasibility of higher resolution narrow band radiometer in disease stress detection.

MATERIALS AND METHODS

The experiment was conducted in *kharif* season of 1996 in split plot design with two varieties (V_1: GAUG-10, V_2: GG-2) and four spraying levels viz., S_1:no spray, S_2: two sprays of Chlorothalonil 0.2 per cent at 30 and 50 days after germination, S_3: three sprays of Chlorothalonil 0.2 per cent at 30, 50 and 70 days after germination, S_4: three sprays- first spray of Chlorothalonil 0.2 per cent at 30 days after germination, second spray of Mancozeb 0.2 per cent at 20 days after first spray, third spray of Carbendezim 0.025 per cent at 20 days after second spray.

Spectral measurements of the experimental plots were made between 1000-1200 hrs IST at weekly interval during all the growth stages of the groundnut crop using multiband ground truth radiometer developed by SAC, Ahmedabad, having filters in spectral bands of (1) 490, (2) 565, (3) 660, (4) 670, (5) 710, (6) 745, (7) 785, (8) 880, (9) 960, (10) 1025, (11) 1080 nm and field of view of 15°. The biometric measurements namely, leaf area index (LAI), green biomass (GBM), dry biomass (DBM) and plant water content (PWC) along with leaf samples for chlorophyll and wax estimation were made on the same day of radiometric observations. The intensity of early and late leaf spot disease was recorded on weekly basis.

The following spectral parameters were used in the analysis: (1) Reflectance ratio (RR) : NIR/R, (2) Slop band combination = Reflectance difference of particular bands/ wavelength difference of particular bands. The disease index was expressed using 1 to 5 scale.

RESULTS AND DISCUSSION

Spectral signatures in relation to disease stress detection and varietal discriminability

It is well known that the ratio NIR/ Red is a good indicator of vegetation and is also useful to distinguish between stressed and unstressed crops. Disease stress could be detected between spectral bands of 6 to 11 (745 nm to 1080 nm) in GAUG-10 and between all spectral bands (490 nm to 1080 nm) during full seed development stage in GG-2 (Fig.1). The disease stress could also be detected between spectral bands of 6 to 11 in both varieties during maturity stage (Fig.2). However both varieties viz., GAUG-10 and GG-2 could be discriminated between spectral bands of 6 to 11 during both stages with disease stress detection (Fig.3).

Spectral bands, biometric parameters and disease index

The biometric parameters namely, dry biomass, plant water content, chlorophyll and wax were best correlated with reflectance in spectral bands of R5 (Red/NIR boundary edge), R1 (High chlorophyll pigment concentration), R2 (chlorophyll absorption minimum) and R11 (Leaf morphology) with correlation coefficient values of -0.33,-0.66,-0.48 and -0.43, respectively. However, LAI did not show any significant correlation with all spectral bands. The disease index for early leaf spot (DI1) and late leaf spot (DI2) showed significant correlations with reflectance in spectral bands of R2 and R1. However, reflectances in spectral bands of R2 and R5 showed significant correlations with all biometric parameters, and disease index, except LAI and wax (Table 1).

Parihar and Navalgund (1992) found that spectral indices derived using data in red and near infrared regions are related to various biometric parameters like leaf area index, biomass and yield.

Spectral ratios, biometric parameters and

Table 1 : Correlation coefficients between different spectral bands, biometric parameters and disease index

Spectral bands	Biometric parameters					Disease index	
	LAI	DBM	PWC	Chlorophyll	WAX	DI1	DI2
R1	-0.05	0.16	-0.66*	-0.36	0.28	0.58*	0.68*
R2	0.18	-0.32*	-0.30*	-0.48*	0.12	0.67*	0.41*
R3	-0.07	0.12	-0.32	-0.23	-0.19	0.07	0.07
R4	-0.04	0.12	-0.26	-0.20	-0.28	0.07	0.04
R5	0.12	-0.05*	-0.28*	-0.47*	0.05	0.59*	0.33*
R6	0.08	-0.25	0.33*	0.16	-0.30	-0.38*	0.60*
R7	0.02	-0.24	0.28*	0.21	-0.04	-0.51*	-0.68*
R8	-0.02	-0.17	0.29*	0.16	-0.37	-0.50*	-0.65*
R9	-0.04	-0.07	0.12	-0.09	-0.40*	-0.35*	-0.51*
R10	-0.11	-0.07	0.07	-0.01	-0.36	-0.38*	-0.40*
R11	-0.15	0.03	0.14	0.03	-0.43*	0.43*	-0.42*

*Significant at 5% level

Table 2 : Correlation coefficients between different spectral ratios, biometric parameters and disease index

Spectral ratios	Biometric parameters					Disease index	
	LAI	DBM	PWC	Chlorophyll	WAX	DI1	DI2
RR54	0.16	-0.47*	-0.06	-0.32	0.44*	0.59*	0.33*
RR64	0.09	-0.33*	0.52*	0.31*	-0.003	-0.39*	-0.55*
RR74	0.03	-0.32	0.47*	0.34	-0.08	-0.53*	-0.67*
RR84	0.01	-0.27	0.49*	0.31	-0.04	-0.49*	-0.59*
RR94	0.01	-0.22	0.41*	0.17	-0.03	-0.40*	-0.53*
RR104	-0.08	-0.20	0.30*	0.23	0.20	-0.44*	-0.44*
RR114	-0.10	-0.15	0.45*	0.25	-0.30	-0.50*	-0.47*
SL34	-0.04	0.12	-0.25	-0.19	-0.29	0.07	0.04
SL53	0.12	-0.34*	-0.28*	-0.47*	0.06	0.60*	0.35*
SL65	0.08	-0.24	0.33*	0.16	-0.30	-0.38*	-0.60*
SL64	0.08	-0.25	0.33*	0.16	-0.30	-0.38*	-0.60*
SL76	0.02	-0.24	0.28*	0.21	-0.39*	-0.51*	-0.68*

*Significant at 5% level

disease index

The reflectance ratio RR74 showed significant correlations with DBM, PWC and disease index for DI1 and DI2. The reflectance in slop band combination of 5 and 4 showed significant correlation with DBM, PWC, chlorophyll and disease index for DI1 and DI2. However wax was best correlated with reflectance ratio RR54 with a correlation coefficient

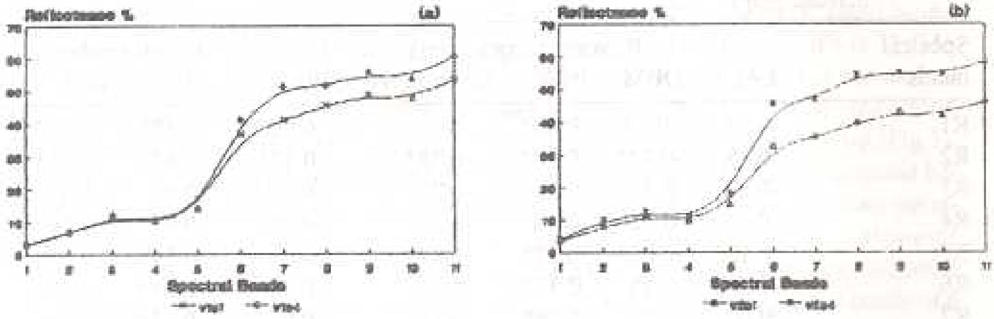

Fig.1 Disease stress detection during full seed development stage

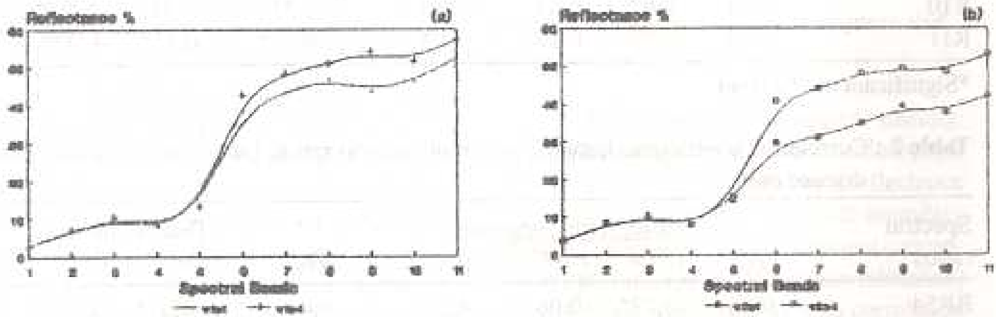

Fig.2 Disease stress detection during maturity stage

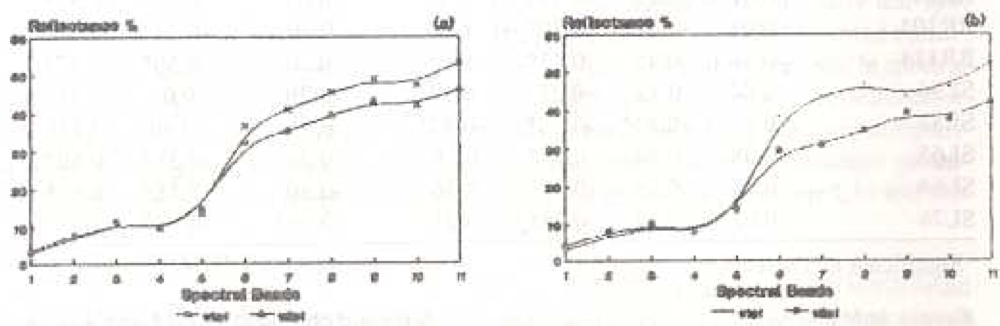

Fig.3 Varietal discrimination (a) full seed development and (b) maturity stage

value of 0.44 (Table2).

Spectral ratio and yield

Correlation studies between different spectral parameters and yield showed that the reflectance ratios RR94, RR104, RR114 and reflectance in slop band combination of 3 and 4 were significantly correlated with final yield with values of -0.34, -0.40, -0.36 and 0.40 respectively during full pod development stage. However, reflectance in slop band combination of 5 and 4 showed significant correlation with yield during maturity stage (Table 3).

It may be summarized that spectral bands of 6 to 11 were found most useful for disease stress detection and varietal discrimination. Reflectance in spectral bands R2 and R5 are more useful in estimating biometric parameters and disease stress. The reflectance in spectral band combinations of 3 and 4 , 5 and 4 could be used to estimate pod yield in groundnut crop.

Table 3 : Correlation coefficients between different spectral ratios and yield

Spectral ratios	Phenophases	
	Full pod	Maturity
RR94	-0.34*	0.27
RR104	-0.40*	0.17
RR114	-0.36*	0.09
SL34	0.40*	-0.03
SL54	0.20	0.35*

* Significant at 5% level

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