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# SPECTRAL SIGNATURES AND IDENTIFICATION OF SOME SUMMER CROPS USING REMOTE SENSING TCHNIQUES

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## ABSTRACT

The improvement of yield forecasting method, is one of most significant potential applications of remote sensing. The spectral quality and intensity of crop reflectance and emittance depend on leaf morphology and pigments, canopy geometry, crop maturity, LA, soil background, management and cultural practices and weather. These parameters might be used on large-scale applications of growth and yield model of corn, rice, cotton and other crops, which their multispectral reflectance properties are not well defined. The objective of this investigation was to assess the potential for estimating canopy variables from remotely sensed reflectance measurements. Reflectances ranges 0.45 up to 0.90 µm wavelength range were acquired during the growth stages of corn, rice and cotton canopies during 2002/03 and 2003/04, with a radiometer (Spectron SE 590) in four wavelength bands (0.45 to 0.52, 0.52 to 0.60, 0.63 to 0.69, and 0.76 to 0.90 µm). Agronomic characterization of the canopy included measurements of growth criteria, i.e plant height, leaf area index (LAI), fresh and dry biomass, and chlorophyll content for all the studied crops. Correlation analyses were used to relate the agronomic variables to reflectance factor. High correlations were found between normalized difference vegetation index (NDVI) and LAI, fresh biomass, and chlorophyll content. The TMs measurements and NDVI values were influenced clearly by the kind of crop at the maximum vegetation stage for corn, cotton and rice. The vegetation index (NDVI) proved to be particularly useful in identifying crops at the maximum vegetation stage.

**Key words:** Remote sensing, Reflectance, Normalized difference vegetation index (NDVI), Leaf Area Index, Biomass, Chlorophyll content

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## INTRODUCTION

Yield forecasting is often the major ultimate goal of work on the use of satellites to monitor crop development. Application of remote sensing techniques on crop identification and monitoring are essentially based, for the moment, on combinations of spectral measurements in the visible and near infrared bands which are available on the Landsat (MSS – TM), NOAA and SPOT satellites. Thematic Mapper (Landsat TM7) has eight spectral bands: 0.45-0.52, 0.52-0.60, 0.63-0.69, 0.76-0.90, 1.55-1.75, 2.08-2.35, 10.4-12.5, and 0.50-0.90 μm. The Thematic Mapper bands were selected for improved spectral characterization of vegetation and geological features. Reflectance of individual leaves are useful in interpreting canopy reflectance patterns. Green leaves generally have low reflectance values between 0.4 and 0.7 μm. Absorption bands are centered at approximately 0.45 and 0.65 μm, resulting in a reflectance peak centered around 0.54 μm. The 0.45 μm absorption band is primarily due to β-carotene **(Ray, 1972)**, while the 0.65- μm absorption band is caused by chlorophyll **(Hoffer, 1978)**. Consequently, on a leaf basis, changes in β-carotene and chlorophyll concentrations TM1 (0.45-0.52 μm), TM2 (0.52-0.60 μm), and TM3 (0.63-0.69 μm); TM1, TM2, and TM3 should respond to the chlorophyll and pigment concentrations in canopy. However, reflectance from healthy canopies in these wavebands becomes approximately constant once a canopy achieves hill ground cover. Consequently, TM1, TM2, and TM3 can be considered to contain information concerning the distribution and condition of the first layer of leaves near the top of canopy.

In the near infrared region (0.7 - 1.3 μm), healthy green leaves are characterized by high reflectance (45 - 50%), high transmittance (45 - 50%), and low absorption (less than 5%). These properties lead to the phenomena known as multiple reflectance. As the number of layers of leaves increase, reflectance continues to nonlinearly increase and may be up to 85% greater than the reflectance from a single leaf **(Meyers, 1970)**. The wavebands of reflected radiation that have been most valuable in these studies are the red (R), and near-infrared (NIR). Reflected red radiation is negatively correlated with chlorophyll concentration and to green leaf area, whereas reflected near-infrared radiation is positively correlated with leaf area. **Knipling (1970) and Pearson & Miller (1972),** showed that the green biomass (amount of plant material) can be estimated by measuring spectral reflectance for crops. Crop yields can be estimated from green biomass measurements. Vegetation indices computed using (red and near-infrared) bands have been related to various vegetation canopy properties, including green LAI **(Price, 1992 and Wiegand *et al* 1991),** canopy biomass **(Anderson and Hanson, 1992)**. The most common of indices are the NIR to red ratio, the normalized difference vegetation index (NDVI) or linear combinations of red and NIR reflectance **Gausman *et al* (1976),** showed that the multiple reflectance effects continue to be detectable through eight layers of leaves. Canopy reflectance in TM4 (0.76-0.90 μm) will respond to changes in leaf area throughout the depth of the canopy.

**Gardner and Blad (1986),** found that the maximum response to changes in LAI over corn crop surface was MMR4/MMR3; where MMR4 is the waveband 0.76 – 0.90 μm and MMR3 is the waveband 0.63 – 0.69 μm. **Heist *et al* (1988),** found that monitoring cereal yield seems to be possible, also high correlation coefficient between vegetation indices and biomass of cereals is detected.

**Shibayama and Akiyama (1991),** indicated that field radiometric measurements can be applied not only for leaf area index or biomass estimation but also for more complex plant information such as grain yield. Spectral estimation for rice should be delayed until 1.5 months after heading (maturity of the grain). **Leblon *et al* (1991),** demonstrated the possibility of estimation the biomass production of flooded rice crops from spectral data, using a remote sensing driven model based on an energetic yield approach, in which the evolution of light interception is estimated from the NDVI temporal profile of the crop through simplified reflectance. This kind of model, although very, simple, is an example of coupling remote sensing measurements with classical models of plant productivity. A further validation of this model will be performed using SPOT data to estimate the spectral profile of a number of further fields in order to estimate their biomass production at various phenological stages. **Price and Bausch (1995),** verified in corn crop, jointly the canopy and soil formulation, the estimation of leaf area index from radiation measurements in the visible and near-infrared.

**Gilabert *et al* (1996),** found that the NDVI and the red-edge position were both useful to describe some phenological stages for corn canopy, due to the significant correlation with biophysical parameters, such as LAI and biomass. Coefficients of determination ($r^2$) for the various relationships ranged from 0.94 to 0.98. However, leaf area index could be best estimated from NDVI by exponential equations, whereas the biomass estimated from the wavelength of the red edge by logarithmic equations.

**Filella *et al* (1995),** found a relationship between reflectance at 550 and 680 nm and canopy chlorophyll A (Chl A) concentration. A linear relationship between red edge parameters and canopy Chl A content is also found.

**Osborne *et al* (2002),** found that with reflectance in the green (510 nm), NIR (705 nm), and MIDIR (1135 nm) regions, chlorophyll meter readings can be predicted with an $R2 > 0.82$ for all sampling dates, indicating the potential of using hyper-spectral imagery as a tool to detect and map variations in plant chlorophyll. While there are numbers of different specific wavelengths that were used to estimate biomass, and grain yield. The range of wavelengths could be useful in determining which reflectance bands are important for detecting biomass or grain yield at different times in the growing season. **Han *et al* (2002),** found that the NDVIs from satellite images (SOPT) were significantly correlated with SPAD data, indicating that SPOT imagery may have potential for detecting chlorophyll levels in corn during the growing season. **Yang *et al* (2004),** mentioned that they achieved a success in using NDVI inputs to classify multi-spectral images having different crops and weed.

The main objective of this research is to investigate spectral reflectance response characteristics of some summer crops (corn, cotton and rice) with agronomic variable during growth stages. The specific objectives are:

* To investigate the effect of changes in agronomic variable on NDVI of corn, cotton and rice plants during differing growth stages.
* To investigate the potential use of NDVI data for identifying these crops.

## MATERIAL AND METHODS

Three field experiments were carried out in Agricultural Experiments Station., Faculty of Agric., Ain Shams univ., Kalubia governorate (at Shalakan) during 2003 and 2004 seasons. Two cotton varieties (Giza88(G88) and Giza85(G85)) were planted in 24$^{th}$ March 2003 and 6$^{th}$ April 2004; two corn verities (Single hybrid 10 (H10); Three way-hybrid 320 (H320)) and also two rice verities (Sakha 101 (S101) and Giza 178 (G178)) were planted in 18$^{th}$ May at the first and second seasons. These plantations were replicated 8 times. The total experimental plots were 48. The texture of the soil was clay. Table (1) shows the chemical and mechanical analysis of the experimental soil.

Morphophysiological measurements (leaf area index and fresh and dry biomass g/m$^2$) were acquired approximately every 15 days throughout the growing season on the same days that spectral measurements were taken. Leaf area index was measured in the lab by an area meter (Model LI-3100). The dry biomass in each date was estimated by multiplying the plant sample of the plot to determine the dry weight per plant. Sample plants were cut off at ground level and taken to the lab, where they were desiccated in oven at 70°C for at lest 24 hours, until a constant weight was obtained, with their shoots, leaves and fruits.

Chlorophyll content was were measured in all corn, cotton and rice plants selected for spectral measurements, using hand–held chlorophyll meter SPAD – 502, which has been developed by Minolta Co., Ltd. (Osaka, Japan). Date of sampling and spectral measurement are shown in Table (2).

Spectral radiance measurements (386nm-1113nm), that are used to determine reflectance, were acquired in approximately 2-weeks intervals with a Spectron SE 590 spectroradiometer, begins from first May until first October. Two spectral measurements were acquired for each plot. The spectroradiometer equipped by scanner having spectral range and 256 channels with band width of 2.8 nm. The third spectral measurement was acquired using white lambertain -panel to normalize the former measurements and increase their accuracy **(Philipson *et al* 1989)**. The scanner of the instrument was fixed using a wooden stand to keep a vertical distance between it and the plant at 1m. The spectral reflectance measurements were collected on clear sunny days during midday hours (between 10.30 a.m. and 2.00 p.m.). Ten spectral and morphophysiological measurements were taken during 2003, and 2004 seasons for cotton, corn and rice.

The individual spectron data files were transferred from the spectron to PC. Data were normalized and the equivalent TM1, TM2, Tm3 and TM4 values were calculated by the aid of EXCEL. Macro was used to automate the former calculations., TM1, TM2 ,TM3 and TM4 correspond to the wavelengths (nm) 0.45 - 0.52 (blue), 0.52 - 0.60 (green),

Table 1. Mechanical and chemical analysis of the experimental site at Ain Shams, Faculty of Agriculture Experimental Station, Shalakan, Kalubia Governorate (Average of 2003 & 2004 seasons)

| a-Chemical analysis | | b- Mechanical analysis | | |
|---|---|---|---|---|
| | | Textural classes (%) | | |
| Saturation percentage(SP) | 60 % | Clay | Coarse sand | 07.8 |
| Available N | 24 ppm | | Fine sand | 25.4 |
| EC at 25 °C | 0.74 ds/m | | Silt | 26.0 |
| pH value | 8.12 | | Clay | 40.8 |

Mechanical analysis were conducted as recommended by **Richards (1954)**, while methods of **Jackson (1967)** were used for chemical analysis, whereas pH value was determined by the method described by **Mclean (1982)**.

0.63-0.69 (red, R) and 0.76 - 0.90 (near infrared, NIR), respectively.

The visible (TM3) and near infrared (TM4) bands are effective in separating the soil and vegetation surfaces because of their differences. The NDVI was low for bare soils and water surfaces and high for green vegetation. The NDVI index ranges from −1.0 to 1.0 was computed according to the following equation suggested by **Rouse *et al* (1974)**:

$$NDVI = (NIR - R) / (NIR + R)$$

The reflectance in R and NIR bands can be obtained from remote sensing measurements acquired by Thematic Mapper – LANDSAT satellite, as follows:

$$NDVI = (TM4 - TM3) / (TM4 + TM3)$$

Correlation analyses were used to relate the agronomic variables to spectral response, with the primary analyses being for data collected between the sowing and harvesting date of plant development. Simple correlation coefficient was computed between yield and each of LAI, biomass and chlorophyll content, also with the spectrum reflectance at each sampling date. Split plot design was used for accuracy in detecting crop impact on NDVI's values. This design help us in identifying crop species within experiment conditions.

## RESULTS AND DISCUSSION

### The relationship between agronomic characteristics and reflectance during development stages

Linear correlation of reflectance (r) of the equivalent LANDSAT TMs wavelength bands and NDVI values vs agronomic characteristics of corn, cotton and rice canopies in the first and second growing seasons i.e., from early stages

Table 2. Date of sampling and spectral measurements for cotton, corn and rice

| No., spectral & Morphophysiological measurements | Season 2003 | | | | | | Season 2004 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | Cotton | | Age (day) | Corn | Rice | Date | Cotton | | Age (day) | Corn | Rice |
| | | Age (day) | Sample | | Sample | Sample | | Age (day) | Sample | | Sample | Sample |
| I | 7 May | 45 | √ | - | - | - | 20 May | 45 | √ | - | - | - |
| II | 5 June | 74 | √ | 19 | √ | √ | 12 June | 68 | √ | 19 | √ | √ |
| III | 25 June | 94 | √ | 39 | √ | √ | 25 June | 81 | √ | 39 | √ | √ |
| IV | 9 July | 108 | √ | 53 | √ | √ | 10 July | 96 | √ | 53 | √ | √ |
| V | 21 July | 120 | √ | 65 | √ | √ | 27 July | 113 | √ | 65 | √ | √ |
| VI | 4 Aug. | 134 | √ | 79 | √ | √ | 14 Aug. | 131 | √ | 79 | √ | √ |
| VII | 18 Aug. | 148 | √ | 93 | √ | √ | 31 Aug. | 148 | √ | 93 | √ | √ |
| VIII | 1 Sept. | 162 | √ | 107 | √ | √ | 14 Sept. | 162 | √ | 107 | √ | √ |
| IX | 17 Sept. | 178 | √ | 123 | √ | √ | 29 Sept. | 178 | √ | 123 | - | √ |
| X | 1 Oct, | 192 | √ | 137 | - | √ | - | - | - | - | - | - |

√ spectral and morphophysiological measurements were taken.
- spectral and morphophysiological measurements were not taken.

(minimum vegetation) to maturing stage of the crops are presented in Tables (3, 4 and 5).

**A- Corn**

Highly significant correlation coefficients were detected between near- infrared reflectance vs leaf area index in the first and second growing seasons during growth stages. This is due to the sensitivity of the near- infrared reflectance to the status of leaf area index during development stages. These results stand in good agreement with those obtained by **Wiegand *et al* (1991) and Gilabert *et al* (1996).** While, the reflectance of the visible wavelengths blue, green, and red were negatively correlated with leaf area index in the first and second growing season.

Highly significant correlation coefficients with high values have been established between NDVI vs leaf area index in the first and second growing seasons. It can be observed that there is an avoid tendency for NDVI to reach plateau at high LAI levels (i.e., LAI > 3, which is reached around the end of July and the first of August).These results showed good agreement with those obtained by **Gilabert *et al* (1996).** They found a positive correlation between leaf area index (LAI) of corn and normalized difference vegetation index (NDVI).

Negatively and highly correlation coefficients are detected between fresh biomass and visible wavelength (TM1, TM2, and TM3), in the first and second growing seasons. While the correlation coefficient of spectral reflectance in near-infrared wavelength and fresh biomass was significant in the first and second growing seasons.

Table (3) shows that NDVI values were highly significant correlated with fresh biomass in the first and second growing seasons. When studying relationship between fresh biomass and NDVI it was observed that the behaviors of fresh biomass and NDVI are similar in this case, where the highest NDVI values were accompanied with the maximum amount of vegetation. Also, the lowest NDVI values were accompanied with the minimum amount of vegetation. **Wiegand *et al* (1991) and Gilabert *et al* (1996)**, reached similar results. Same relationships were detected with fresh leaves, because, the fresh leaves are clearly influenced by LAI and fresh biomass.

The spectral reflectance of corn was poorly correlated with dry biomass at near- infrared wavelength in the first and second growing seasons. This is due to that, the reflectance in near- infrared band (TM4) was sensitive to changes in fresh and dry biomass only through the first period of the growing season and in the second period of the growing season reflectance was negatively correlated to further increases in biomass. This asymptotic behavior has been reported by several authors **(Ahlrichs and Bauer (1983), Wiegand *et al* (1991), Gilabert *et al* (1996) and Abd El-Gawad *et al* (2000)).** These authors interpreted the relationships of near- infrared reflectance to LAI. They concluded that the spectral measurements appear not to be related to the amount of total biomass present, but rather to the amount of green vegetation, particularly leaves. In the first period of the growing season, fresh and dry biomasses were significantly correlated with reflectance because at the early stages green leaves constitute the majority of

Table 3. Correlation of reflectance (r) at TMs band and NDVI values with agronomic characteristics of corn canopies

| Spectral bands | Chlorophyll content (SPAD unit) | Fresh leaves (g/m²) | Dry leaves (g/m²) | Fresh Biomass (g/m²) | Dry Biomass (g/m²) | LAI |
|---|---|---|---|---|---|---|
| | | | 2003 | | | |
| TM1 | -.938** | -.840* | -.804* | -.759* | -.505 | -.836* |
| TM2 | -.939** | -.833* | -.849* | -.807* | -.590 | -.818* |
| TM3 | -.931** | -.973** | -.872* | -.816* | -.484 | -.972** |
| TM4 | .915** | .917** | .798* | .758* | .364 | .949** |
| NDVI | .978** | .959** | .896** | .858* | .526 | .956** |
| | | | 2004 | | | |
| TM1 | -.829* | -.950** | -.866* | -.788 | -.417 | -.962** |
| TM2 | -.725 | -.866** | -.857* | -.836* | -.545 | -.917** |
| TM3 | -.767 | -.822* | -.948** | -.955** | -.712 | -.912** |
| TM4 | .888* | .902** | .829* | .708 | .306 | .852* |
| NDVI | .895* | .903** | .975** | .922** | .605 | .936** |

*,**. Correlation is significant at the 0.05 and 0.01 level, respectively.

plant biomass. However, after the plants reached their maximum leaf green, the participation percentage of green leaves in the total dry biomass was gradually deceased in the second period of the growing season. Similar results were obtained between NDVI and dry biomass, because high correlations were recorded between NDVI values and near infrared reflectance.

Data in Table (3), exhibit highly significant and negatively correlations between the visible wavelengths reflectance (blue, green, and red) vs chlorophyll content in the first and second growing seasons. This finding may be due to the adverse relationship between visible wavelengths reflectance vs and chlorophyll concentration. **Thomas and Gausman (1977)**, reached similar conclusion. On the other hand, the reflectance in the near- infrared wavelength and NDVI values were positively correlated with chlorophyll content. These results stand in good harmony with those of **Tumbo *et al* (2002)**, whom found a strong correlation between chlorophyll reading (in SPAD unit) and near the infra red/green (NIR/G)ratio ($r^2$= 0.94).

**B- Cotton**

Correlation coefficient of cotton exhibited similar results to those obtained in corn. The near infrared reflectance and NDVI values were highly significantly correlated with leaf area index and fresh biomass in the first and second seasons.

Table 4. Correlation of reflectance (r) at TMs band, and NDVI values with agronomic characteristics of cotton canopies

| Spectral bands | Chlorophyll content (SPAD unit) | Fresh leaves ($g/m^2$) | Dry leaves ($g/m^2$) | Fresh biomass ($g/m^2$) | Dry biomass ($g/m^2$) | LAI |
|---|---|---|---|---|---|---|
| | | | 2003 | | | |
| TM1 | -.519 | -.670* | -.609 | -.413 | -.316 | -.786* |
| TM2 | -.403 | .094 | .190 | .333 | .432 | -.184 |
| TM3 | -.418 | -.279 | -.154 | -.102 | .082 | -.522 |
| TM4 | .542 | .933** | .914** | .891** | .827** | .798** |
| NDVI | .718* | .879** | .854** | .753* | .676* | .817** |
| | | | 2004 | | | |
| TM1 | -.113 | .010 | .208 | .133 | .144 | .134 |
| TM2 | .171 | .125 | .212 | .229 | .197 | .238 |
| TM3 | .212 | .279 | .510 | .373 | .435 | .286 |
| TM4 | .670 | .801* | .761* | .829* | .805* | .745* |
| NDVI | .867** | .830* | .706 | .754* | .730* | .804* |

*,** Correlation is significant at the 0.05 and 0.01levels, respectively .

Table 5. Correlation of reflectance (r) at TMs band, and NDVI values with agronomic characteristics of rice canopies

| Spectral bands | Chlorophyll content (SPAD unit) | Fresh biomass ($g/m^2$) | Dry biomass ($g/m^2$) | LAI |
|---|---|---|---|---|
| | | 2003 | | |
| TM1 | -.444 | -.911** | -.609 | -.727 |
| TM2 | -.612 | -.890** | -.518 | -.840* |
| TM3 | -.726 | -.822* | -.400 | -.851* |
| TM4 | .276 | .817* | .588 | .762* |
| NDVI | .597 | .868* | .494 | .833* |
| | | 2004 | | |
| TM1 | -.506 | -.791 | -.478 | -.611 |
| TM2 | -.630 | -.761 | -.392 | -.706 |
| TM3 | -.712 | -.724 | -.331 | -.706 |
| TM4 | .381 | .795 | .517 | .922** |
| NDVI | .607 | .821* | .463 | .840* |

*,** Correlation is significant at the 0.05 and 0.01 levels, respectively.

On the other hand, the spectral reflectance (TM4) and NDVI were significantly correlated with dry biomass, in the contrary of corn and rice crops, and this is may be due to the length of vegetation period in cotton as compared with that in corn and rice crops. Also, NDVI values and near-infrared reflectance were positively correlated with chlorophyll content in the first and second seasons (Table, 4).

**C- Rice**

Highly significant correlations were detected between NDVI and near-infrared reflectance on one hand and leaf area index and fresh biomass on the other hand throughout the first and second seasons (Table 5).

Data in Table (5) reveal that chlorophyll content was positively correlated with near-infrared reflectance and NDVI during the two seasons.

**NDVI performance throughout crop development**

A number of mathematical formulae using visible and near- infrared reflectance, are called radiometric vegetation indices, have been proposed for relating radiometric measurements in the visible and near-infrared wavelength intervals to the amount of vegetation present. **Perry and Lautenschlager (1984)** discussed 15 such radiometric vegetation indices, and formal relationships among them. Recently attention has been focused on a commonly used index, the normalized difference vegetation index (NDVI) of **Rouse *et al* (1974).** The basis for NDVI is related to the abrupt increase of vegetation reflectance at the wavelength $\lambda = \lambda_0 \approx 0.7$ µm. This increase may be expressed by the formula:

$$NDVI = \Delta \ln [R(\lambda_0)] = \frac{R(\lambda_0 + \delta\lambda) - R(\lambda_0 - \delta\lambda)}{R(\lambda_0 + \delta\lambda) + R(\lambda_0 - \delta\lambda)} = (R2 - R1)/(R2 + R1)$$

Where $\delta\lambda$ is of the order of 0.1-0.2 µm, and the visible and near-infrared reflectance [$R1 = R(\lambda 0 - \delta\lambda)$, $R2 = R(\lambda 0 + \delta\lambda)$] may be obtained by remote sensing measurements from a number of satellites, such as Landsat, SPOT, and NOAA series, after division by the solar constant. The index range from -1.0 to 1.0.

Most vegetation indices (VIs) are qualitatively related to the vegetation amount (LAI, for example) and have been used as an indicator of vegetation growth **(Tuker 1979, Wiegand *et al* 1991 and Gutman, 1991).**

Figs. (1) reveals NDVI values during development stages of the corn, cotton and rice crops in the first and second seasons.

NDVI values illustrated low values at early growth stages (0.25 & 0.37) 19 days after planting (DAP), (0.21 & 0.20) 19 DAP, and (0.46 & 0.46) 45 DAP for corn, rice and cotton in the first and second seasons, respectively. Lower values are considered as an indication of low vegetation surface and low amount of green vegetation in comparative to soil surface. This is true because the soil incomplete covering by crops at early age in particular. The agronomic characteristics recorded small figures for LAI, and fresh and dry biomass. NDVI values are considered as indicators of high values of green vegetation surface and amount of

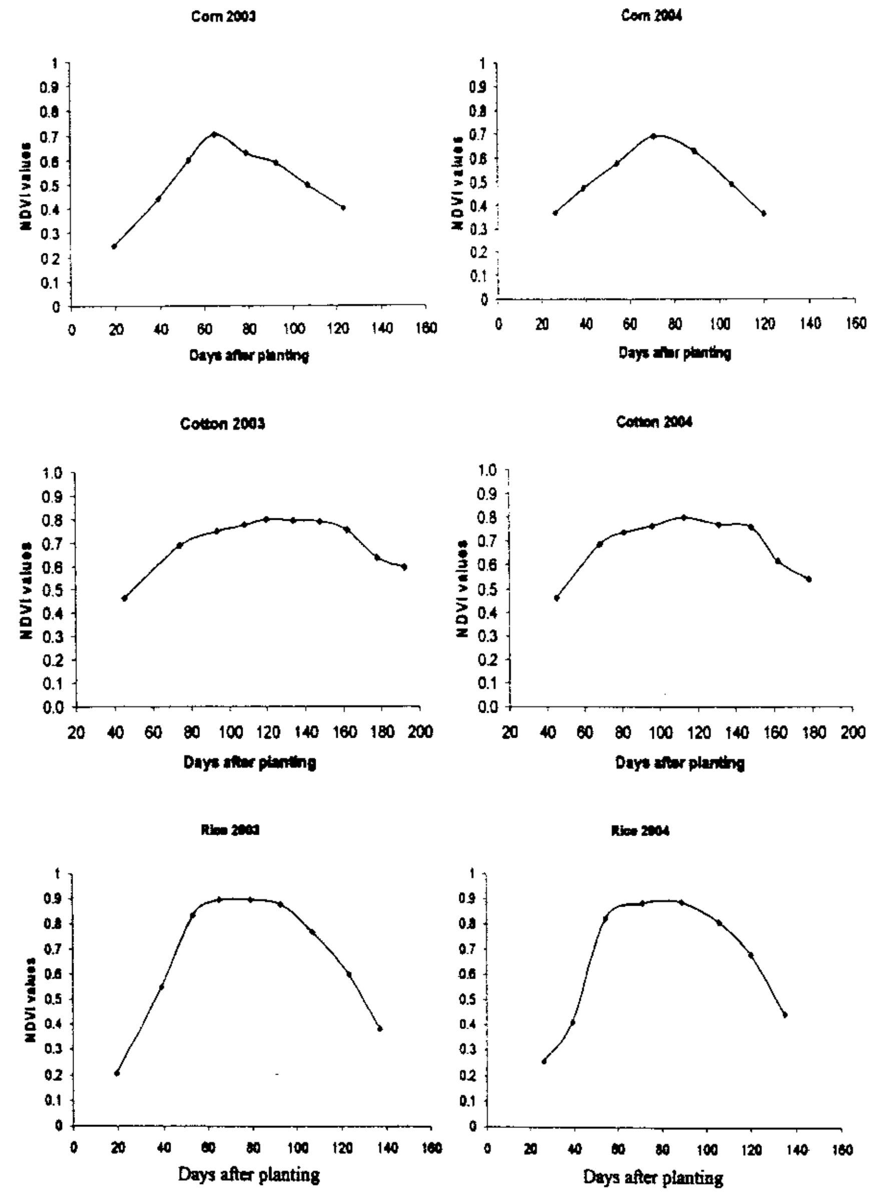


Fig. 1. The relationship between NDVI values and developmental stages of corn, cotton, & rice crops in 2003 & 2004 seasons

green vegetation, Because NDVI values are mainly green vegetation amount dependant, this was achieved from middle July to middle August for all crops. This holds true because the agronomic data recorded the highest LAI, biomass and number of leaves. The deficit in NDVI value at belated stages could be attributed to the decrement in the amount of green vegetation due to leaf senescence (**Gallo and Flesch, 1989, Wiegand *et al* 1991 and Gilabert *et al* 1996).**

**Crop species impact on spectral reflectance and NDVI values**

When studying changes in NDVI values during growth stages for corn, cotton and rice crops, it was noticed the same behavior of changes (Fig. 2). The minimum NDVI values were recorded at early and belated stages, this might be attributed to a reduction in vegetation cover, biomass, LAI and chlorophyll content in the early growth stage. This decrease in these parameters -by the time- had an obvious effect on the studied crops during maturity (belated stage) which lead to a reduction in fresh biomass, green leaf area and chlorophyll content. On the other hand, maximum NDVI values were recorded at the highest fresh biomass, LAI and chlorophyll content (middle July to middle August).

NDVI values of the three crops were interlaced clearly at the first period of the first and second seasons, respectively (from 1-May to 15-Julay & from18-May to 15-July) and at the end period of both seasons (from 18-August to 31-Sptemper). The difference of NDVI values throughout the maximum vegetation stages (from 15-Julay to 15-August) were very clear, in another word there were no interloping. This result leads us to analyze NDVI values during this date (Table, 6). The previous results exhibited that crop species (corn, cotton and rice) had a significant effect on TMs measurements and NDVI values.

Figure (2) shows that rice crop recorded the highest NDVI value as compared with cotton and corn crops being (0.90, 0.80 and 0.71 for rice, cotton and corn, respectively on 21-July-2003 & 0.89, 0.80 and 0.69 for rice, cotton and corn, respectively on 27-July-2004). This might be due to the increase in the number of intercellular air space of rice leaf tissue as compared with cotton and corn. Similar results have been reported by several authors, (**Gausman *et al* 1969 and Barret & Curtis 1982). Gausman *et al* (1969)** quantitatively related near-infrared reflectance to number of intercellular air space. They noticed that reflectance increased with an increase in number of air space, because diffused light passed more often from a high (hydrated cell walls, about 1.4) to low (intercellular air. 1.0) reflective index.

Table (6) shows that there were no significant differentiations between the cultivars in each crop, so we can not identificate the cultivars in each crop depending on reflectance measurements.

In summary, it is possible to identificate corn, cotton and rice crops depending upon deferential NDVI values at the maximum vegetation timing (from middle July to middle August) within experiment conditions.

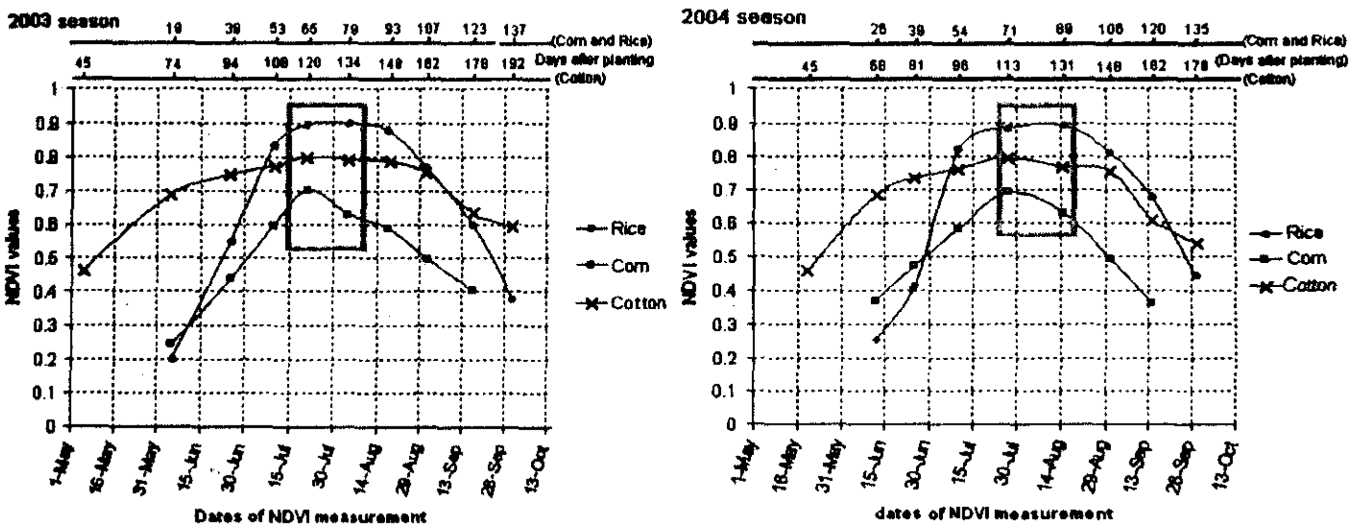


Fig. 2. NDVI changes throughout the growing season for corn, cotton and rice (2003 & 2004)

Table 6. Effect of crop species and cultivars on the spectral reflectance and NDVI values

| | | TM1 0.45-0.52 µm | TM2 0.52-0.60 µm | TM3 0.60-0.69 µm | TM4 0.67-0.90 µm | NDVI |
|---|---|---|---|---|---|---|
| | | | | 2003 | | |
| Crop species | | | | | | |
| Corn | | .0497 c | .0778 c | .0650 b | .3967 a | .7087 a |
| Cotton | | .0347 b | .0748 b | .0571 b | .5134 b | .8048 b |
| Rice | | .0179 a | .0289 a | .0200 a | .3844 a | .8963 c |
| Cultivar | | | | | | |
| Corn | H10 | .0554 c | .0873 b | .0718 b | .4649 cd | .7320a |
| | H320 | .0441 b | .0684 b | .0582 b | .3286 a | .6854a |
| Cotton | G85 | .0346 b | .0736 b | .0586 b | .5165 d | .8041b |
| | G88 | .0348 b | .0759 b | .0555 b | .5104 d | .8055b |
| Rice | S101 | .0201 a | .0311 a | .0214 a | .4174 bc | .9028c |
| | G178 | .0156 a | .0266 a | .0186 a | .3515 ab | .8897c |
| | | | | 2004 | | |
| Crop species | | | | | | |
| Corn | | .0552 c | .0914 c | .0809 c | .5060 c | .6920 a |
| Cotton | | .0385 b | .0650 b | .0565 b | .4405 b | .8006 b |
| Rice | | .0224 a | .0346 a | .0241 a | .3937 a | .8853 c |
| Cultivar | | | | | | |
| Corn | H10 | .0529 c | .0882 c | .0832 c | .4347 ab | .6953 a |
| | H320 | .0575 c | .0947 c | .0786 c | .4464 ab | .6887 a |
| Cotton | G85 | .0350 b | .0648 b | .0600 b | .4840 bc | .8023 b |
| | G88 | .0420 b | .0653 b | .0530 b | .5282 c | .7990 b |
| Rice | S101 | .0240 a | .0385 a | .0250 a | .3947 a | .8816 c |
| | G178 | .0208 a | .0307 a | .0232 a | .3928 a | .8889 c |

Significance at 0.05 level

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مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس ، القاهرة ، م٥٠ ، ع(١)، ٦٥-٨٢ ، ٢٠٠٥

# البصمة الطيفية لبعض محاصيل الحقل الصيفية وتمييزها باستخدام تقنيات الاستشعار عن بعد

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أقيمت تجربة زراعية في محطة البحوث والتجارب الزراعية التابعة لكلية الزراعة جامعة عين شمس في الموسمين الزراعيين ٢٠٠٣ -٢٠٠٤ لدراسة الصفات الانعكاسية لأهم محاصيل الحقل الصيفية وهي الذرة والقطن و الأرز في المجال الطيفي ٠,٣٩-١,١ ميكرومتر المتضمن أربع نطاقات طيفية والتي تكافئ النطاقات الطيفية الأربعة المستخدمة في القمر الصناعي الأمريكي لاندسات Thematic Mapper, (TM) وهي الزرقاء (٠,٤٥-٠,٥٢ ميكرومتر TM1) ، الخضراء (٠,٥٢-٠,٦٠ ميكرومتر TM2) ، الحمراء (٠,٦٣-٠,٦٩ ميكرومتر TM3) وأخيراً تحت الحمراء (٠,٧٦-٠,٩٠ ميكرومتر TM4) و حساب الدليل الطبيعي للاختلافات الخضرية NDVI عند مراحل النمو المختلفة لهذه المحاصيل ، وذلك بهدف دراسة العلاقة بين بعض صفات النمو للمحاصيل الثلاثة السابقة الذكر (دليل المساحـــة الورقيـــة - الوزن الجاف والغض للنبات - محتوى الكلوروفيل) وقياسات الانعكاس الطيفـــي من أجـــل تحديد تأثير اختلاف نـــوع المحصـــول على الانعكاسات الطيفية وقيم الـــ NDVI خلال مراحل التطور المختلفة لهذه المحاصيل. وأخيراً معرفة امكانية تمييز هذه المحاصيل بالاعتماد على قيم الـــ NDVI .

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي.

* وجد ارتباط موجب ومعنوي بين الانعكاسات الطيفية وقيم الـــ NDVI من جهة، وكل من دليل المساحة الورقية ، الوزن الجاف والغض للنبات و تركيز الكلوروفيل من جهة أخرى.
* كان لقيم الـــ NDVI سلوك متشابه خلال مراحل تطور هذه المحاصيل حيث كانت

قيمها منخفضة في بداية الموسم لترتفع مع تقدم النبات في النمو ثم لتصل إلى الذروة مع وصول المحاصيل الثلاثة للذروة من حيث الوزن الغض ودليل المساحة الورقية ثم تعود لتنخفض ثانية مع اتجاه النبات نحو النضج. مع ملاحظة وجود تقارب بين قيم الـــ NDVI للمحاصيل الثلاثة في بداية الموسم وفي نهايتـــه أما في مرحلـــة النمو الأعظم كانت القيم متباعدة بشكـــل واضـــح.

لوحظ وجود فروق معنوية بين قيم الـــ NDVI في مرحلة النمو الأعظم، نتيجة لاختلاف نوع المحصول، وبالتالي يمكن القول أنه بالإمكان التمييز بين هذه المحاصيل (الذرة – القطن – الأرز) بالاعتماد على الاختلافات في قيم الـــ NDVI في مرحلة النمو الأعظم والتي توافق الفترة الواقعة ما بين منتصف يوليو إلى منتصف أغسطس تقريباً في ظل ظروف التجربة المقامة.

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