Annals Agric. Sci., Ain Shams Univ., Cairo, 50(2), 481-498, 2005

ESTIMATION OF SOME SUMMER CROPS AREA AND YIELD PREDICTION USING REMOTE SENSING TECHNIQUES

[32]

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ABSTRACT

Studies aiming to perfect techniques for identifying crops and estimating acreage and yield of crops have been intensified with improvements in the technology and the increased availability of space imagery. The current study tries to investigate; firstly, the relationship between the spectrum reflectance and NDVI of some important strategy crops canopies in Egypt i.e. cotton, corn, and rice during the different growth stages. Such data may lead to detect if it's possible to forecast crop yield early by remote sensing techniques. The portable hand reflectance radiometer was used to simulate that of Landsat satellite. Secondly, this study tries also to conduct acceptably accurate crop identification and production estimates in study area (El-Kanater ElKhayrya district), using satellite sensor data (Landsat satellite) and automated data classification techniques.

Crop species i.e corn, cotton and rice had a significant effect on NDVI values at the fifth and sixth stages of these crops. Therefore, it is possible to identificate these crops depending upon deferential NDVI values at the maximum vegetation timing (from middle July to middle August). Highly significant correlation coefficients have been established between NDVI values and economic yield of the crops at stages 5 and 6 (from middle July to middle August) in both growing seasons. The linear regression clarified high significant relationship between NDVI values and economic yield for three crops at the stages 5 and 6. The supervised classification outputs of the study area (ElKanater ElKhayrya district) are 6 classes as follow: rice, corn, other crops, urban, water, and others. Results showed that the area of rice crop were 3587.79 fed and 12055.93 fed for corn crop. Average accuracy of rice and corn area estimation from LANDSAT-7 ETM+ data recorded 88.68%.

Keywords: Normalized Difference Vegetation Index (NDVI), Remote Sensing, Classification, Cotton, Corn, Rice.

INTRODUCTION

More than a dozen vegetation indices (VIs) have been developed by linearly combining or ratioing reflectances in the red and in the NIR spectral regions. The most commonly used VI is the normalized difference vegetation index (NDVI):

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(Received August 13, 2005)
(Accepted September 10, 2005)

$$NDVI = 0\ (a_{NIR} - a_{RED}) / (a_{NIR} + a_{RED})$$

Where: α is reflectance in red or NIR spectral region. Most VIs are qualitatively related to the vegetation amount (LAI, biomass, % cover, for example) and have been used as an indicator of vegetation growth and yield **(Tucker (1979), Wiegand et al (1991), and Abd-El-Gawad et al (2000)).**

Denison *et al* (1996) found a significant correlation between seasonally integrated NDVI and corn yield. **Ma *et al* (1996)** found that the NDVI that measured pre-anthesis and anthesis for corn crop, was strongly correlated with grain yield at harvest, the reflectance measured at post anthesis differentiated hybrid differences in leaf senescence. They suggested that light reflectance measurements prior to anthesis predict grain yield. **Diker *et al* (2004)** carried out a study to asses the relationship between corn yield and the NDVI. Arial images were acquired on July 21 (DOY 203) and August 10 (DOY 229) 2000 using Duncan Tech MS3100 multispectral digital camera. They found a strong relationship between corn yield and NDVI on DOY 203 (V16 full canopy stage). **Perumal *et al* (1999)** measured canopy spectral reflectance in a field experiment at the boll development stage in elite cotton cultivars, and they manifested that Infrared-red reflectance and NDVI traits were positively associated with seed-cotton yield (SCY) in those cultivars. **Domenikiotis *et al* (2004)** showed that early estimation of cotton yield trend was feasible by the use of VCI as extracted from NDVI, when they used NOAA/AVHRR satellite data. **Shibayama and Akiyama (1989)** found that the spectral reflectance values of rice crop in the VIS bands were lowest when the panicles emerged, whereas the values at 840 and 1100 nm increased until the time when the grains reached maturity.

Satellite data can significantly contribute to agricultural monitoring. The reflected radiation, as recorded by satellite sensors, provides an indication of the type, density and condition of canopy. **Quarmby *et al* (1993)** investigated the potential of using the NDVI derived from the AVHRR data to monitor crop yield in north Greece in 1986-89, and found a high degree of yield estimation accuracy using simple linear relationship between NDVI and yield for wheat, cotton, rice and maize crops. The estimation stabilized 50-100 days prior to harvest, ending an early assessment of crop yield to be made. **Ray *et al* (1994)** applied the supervised classification to estimate cotton production in India using IRS-1B and metrological data. After mosaic king two scenes of LISS-1 data, the study area boundary was used to cut down the target image. Maximum likelihood classification scheme was used for crop identification and acreage estimation. **Fang (1998)** applied two strategies to rice crop area estimation using Landsat satellite data. These two methods were designated strategy A (cut and classify), and strategy B (classify and cut). The results indicated that strategy B is better than strategy A in the unsupervised classification-cluster process and the rice crop area was estimated with an accuracy of over 81% for semi-late rice and 90% for early rice. **El-Mowelhi *et al* (2003)** evaluated the accuracy of different classification techniques (Maximum likelihood, Maximum likelihood with Null class, Minimum distance, Parallel piped with maximum likelihood parameter, and Parallel piped), and Kappa is used to evaluate the classification results of a LANDSAT Thematic Mapper (TM) scene acquired 23/8/1997.The study area selected for the evaluation of different classification techniques is Abu-Hammad district in Sharkeya Governorate. The seven categories of land cover for this area included cotton, rice, other crops, urban, water, new cultivated land, and bare soil. They concluded that the maximum likelihood classification technique is recommended to be used for locating rice and cotton areas as it produces the lowest variations between the classified and actual crop areas.

This work was raised to investigate the relationship between the spectrum reflectance of canopy and NDVI of some important strategy crops in Egypt i.e. corn, cotton and rice during different growth stages. Such investigation may lead to identificate these crops their cultivated area, and forecast their yield using remote sensing techniques.

MATERIAL AND METHODS

1. Filed experiment

Six 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 (cv. Giza88, and Giza85) were planted in 24th March 2003 and 6th April 2004; two corn verities (cv. Single hybrid 10, and Three way-hybrid 320) and also two rice verities (cv. Sakha 101, and Giza 178) were planted in 18th May and 25th at the first and second seasons, respectively. These plantations were replicated 8 times. The total experimental plots were 48. The texture of the soil was clay.

Spectral reflectance and NDVI were acquired in approximately 2-weeks intervals with a Spectron SE 590 spectroradiometer, begins from first May until first October (Table 1). Two spectral measurements were acquired for each plot. The third spectral measurement was acquired using white lambertain -panel to normalize the former measurements and increase their accuracy (**Philipson., *et al* 1989**).

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

The NDVI index ranges from –1.0 to 1.0 was computed according to the following equation suggested by **Rouse *et al* (1974)**.

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

Simple correlation coefficient was computed between yield and NDVI at each sampling date. Split plot design was used for accuracy in detecting crop impact on NDVI's values. This design helps us in identifying crop species within experiment conditions.

2- Remote sensing data

Depending on spectral reflectance and NDVI value that measured from hand held radiometer of the field experiment,

Table 1. Date of sampling and spectral measurements for cotton, corn, and rice.

No., Stages	Date of sampling	Season 2003								
		Cotton			Corn			Rice		
		Phenological stages	Plant age (Days)	Sample	Phenological stages	Plant age (Days)	Sample	Phenological stages	Plant age (Days)	Sample
1	7 May	Vegetation growth	45	√	x	x	x	x	x	x
2	5 June	Beginning square	74	√	Fifth leaf	19	√	Tiller initiation	19	√
3	25 June	Square	94	√	Tenth leaf	39	√	Stem elongation	39	√
4	9 July	Beginning flower	108	√	Fifteenth leaf	53	√	Maximum tillering	53	√
5	21 July	Flowering	120	√	Tasseling	65	√	Booting	65	√
6	4 Aug.	Seed formation	134	√	Silking	79	√	Beginning heading	79	√
7	18 Aug.	Beginning open boll	148	√	Milk	93	√	Completely heading	93	√
8	1 Sept.	Open 50% boll	162	√	Dough	107	√	Milk	107	√
9	17 Sept.	Open most boll	178	√	Harvesting	123	√	Dough	123	√
10	1 Oct,	Harvesting	192	√	x	x	x	Harvesting	137	√
					Season 2004					
1	20 May	Vegetation growth	45	√	x	x	x	x	x	x
2	12 June	Beginning square	68	√	Fifth leaf	19	√	Tiller initiation	19	√
3	25 June	Square	81	√	Tenth leaf	32	√	Stem elongation	32	√
4	10 July	Beginning flower	96	√	Fifteenth leaf	47	√	Maximum tillering	47	√
5	27 July	Flowering	113	√	Tasseling	64	√	Booting	64	√
6	14 Aug.	Seed formation	131	√	Silking and Milk	82	√	heading	82	√
7	31 Aug.	Beginning open boll	148	√	Dough	99	√	Milk	99	√
8	14 Sept.	Open 50% boll	162	√	Harvesting	113	√	Dough	113	√
9	29 Sept.	Harvesting	178	√	x	x	x	Harvesting	128	√
10	x	x	x	x	x	x	X	x	x	X

√, x Spectral and agronomic characteristics measurements were taken and not taken, respectively.

one LANDSAT-7 ETM+ (path 177, raw 39) satellite image was acquired for the studied area in date 24/7/2004. The image processing system used ERDAS 6.8 and PCI software is also supplementally used 1:25 000 scale topographic maps and others ancillary information were also used in this study. The study area selected for crop area estimation by classification techniques was chosen to be El-Kanater El-Khayrya district in Kalubia Governorate.

Field trip was carried out to the study area to collect the required samples, (as ground truth or training area), necessary for the classification process. Topographic maps of the regions with a scale of 1:25 000, were utilized during this mission.

Methodology for data processing

Data processing included eight steps

Step 1: LANDSAT-7 ETM+ digital data (scene 177-39) were loaded on sun work station.

Step 2: Geometric correction: Raw data of LANDSAT-7 ETM+ image was corrected by using ground control points GCPs, which represent features of known ground locations that can be accurately located on the digital imagery. Erdas Imagine software (version 8.6) was used in geometric correction process images with ETM (Egyptian Transverse Mercator).

Step 3: Extract sub-scene from the ETM^+ image that includes rectangular image circumscribing the study area (El-Kanater ElKhayrya district).

Step 4: The administrative boundary of ElKanater ElKhayrya district (ARC/INFO vector format) was displayed on the screen and was cut down. The administrative boundary of ElKanater ElKhayrya district was extracted from the topographic map.

Step 5: The inappropriate area outside the administrative boundary was masked out.

Step 6: The training areas are superimposed on the images as polygons using surveying instruments and the natural boundaries on the maps like canals and roads. Each polygon is assigned a number that indicates certain class of land cover. The collected data are (cotton, rice, corn, other crops, urban, water). Other crops include vegetables, trees, or any different type of crops. The main characteristics of the training areas must be homogenous and clear.

Step 7: Apply the supervised classification using the same training areas by Maximum likelihood techniques.

Step 8: Calculated the area of each crop class in feddan obtained from the classified image in 2004.

RESULTS & DISCUSSION

1- Field radiometric measurements

A- NDVI and crop species relationships

Table (2) reveals NDVI values during development stages of the cotton, corn 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 & 0.26) 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

Table 2. Reflectance, and NDVI values during development stages of cotton, corn and rice in 2003 and 2004 seasons.

No. stage	Phenological stage	Date	Plant age (day)	TM3	TM4	NDVI	Phenological stage	Date	Plant age (day)	TM3	TM4	NDVI	Phenological stage	TM3	TM4	NDVI
									2003							
				Cotton						Corn					Rice	
Stage1	Vegetation growth	7-May	45	0.08	0.22	0.47										
Stage2	Beginning square	5-Jun	74	0.06	0.32	0.69	Fifth leaf	5-Jun	19	0.15	0.25	0.25	tiller initiation	0.09	0.14	0.21
Stage3	Square	25-Jun	94	0.06	0.39	0.75	Tenth leaf	25-Jun	39	0.12	0.30	0.44	stem elongation	0.07	0.27	0.55
Stage4	Beginning flower	9-Jul	108	0.05	0.43	0.78	Fifteenth leaf	9-Jul	53	0.08	0.33	0.60	Maximum tillering	0.03	0.37	0.83
Stage5	Flowering	21-Jul	120	0.05	0.48	0.80	Tasseling	21-Jul	65	0.07	0.40	0.70	Booting	0.02	0.38	0.90
Stage6	seed formation	4-Aug	134	0.05	0.47	0.79	Silking	4-Aug	79	0.09	0.38	0.63	Beginning heading	0.02	0.40	0.90
Stage7	Beginning open boll	18-Aug	148	0.06	0.53	0.79	Milk	18-Aug	93	0.09	0.35	0.59	Completely heading	0.02	0.37	0.88
Stage8	Open 50% boll	1-Sep	162	0.07	0.45	0.75	Dough	1-Sep	107	0.10	0.29	0.50	Milk stage	0.04	0.35	0.77
Stage9	Open most boll	17-Sep	178	0.07	0.32	0.63	maturity and harvesting	17-Sep	123	0.16	0.28	0.28	Dough ripe stage	0.08	0.33	0.60
Stage10	Harvesting	1-Oct	192	0.08	0.30	0.59		1-Oct					Harvesting	0.14	0.30	0.38

Table 2. Cont.

No. stage	Phenological stage	Date	Plant age (day)	TM3	TM4	NDVI	Phenological stage	Date	Plant age (day)	TM3	TM4	NDVI	Phenological stage	TM3	TM4	NDVI
									2004							
Stage1	Vegetation growth	20-May	45	0.08	0.21	0.46										
Stage2	Beginning square	12-Jun	68	0.05	0.29	0.69	Fifth leaf	12-Jun	19	0.12	0.29	0.37	tiller initiation	0.07	0.12	0.26
Stage3	Square	25-Jun	81	0.06	0.42	0.74	Tenth leaf	25-Jun	32	0.10	0.30	0.47	stem elongation	0.11	0.26	0.41
Stage4	Beginning flower	10-Jul	96	0.06	0.48	0.76	Fifteenth leaf	10-Jul	47	0.08	0.34	0.58	Maximum tillering	0.03	0.31	0.82
Stage5	Flowering	27-Jul	113	0.06	0.51	0.80	Tasseling	27-Jul	64	0.08	0.44	0.69	Booting	0.02	0.39	0.89
Stage6	seed formation	14-Aug	131	0.07	0.50	0.77	Silking and Milk	14-Aug	82	0.08	0.37	0.63	Completely heading	0.02	0.39	0.89
Stage7	Beginning open boll	31-Aug	148	0.09	0.54	0.72	Dough	31-Aug	99	0.10	0.28	0.49	Milk stage	0.03	0.35	0.81
Stage8	Open 50% boll	14-Sep	162	0.09	0.37	0.61	Maturity and harvesting	14-Sep	113	0.12	0.24	0.36	Dough ripe stage	0.06	0.35	0.68
Stage9	Harvesting	29-Sep	178	0.09	0.30	0.54		29-Sep					Harvesting	0.13	0.30	0.40

surface. This is true because the soil was in 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 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 (**Wiegand, *et al* 1991 and Gilabert *et al* 1996**).

When studying changes in NDVI values during growth stages for corn, cotton and rice crops, it was noticed the same behavior of changes (Fig. 1). NDVI values of the three crops were interlaced clearly at the first period of the first and second seasons, (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 (Fig. 1). This result leads us to analyze NDVI values during this date. The previous results exhibited that crop species (corn, cotton and rice) had a significant effect on TMs measurements and NDVI values.

Figure (1) 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 Barrett & 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.

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. (**Al-Khaled *et al* 2005**) achieved the same results.

B- NDVI and reflectance values and economic yield relationship

This subject was conducted to select the relevant agronomic stage that has clear relationship with the yield, which may be used as an early yield forecasting indicator.

The correlation coefficients between the reflectance measurements and NDVI values vs seed cotton yield and grain yield of corn and rice are depicted in Table (3). Seed cotton yield and grain yield, at stages (2, 3, 4, 5, 6, 7 and 8) in particular, showed significant correlation coefficients vs NDVI and reflectance values. Especially, at stage 5 and stage 6, the NDVI value recorded high significant correlation with seed cotton yield and grain yield of corn and rice, in both seasons (Table3). An early forecasting for yield of cotton, corn and rice may be advised and guided by measuring the value of NDVI at stages 5 and 6. Many authors found a strong relationship between NDVI and economic yield of corn (**Ma *et al* 1996; Quarmby *et al* 1993; Diker *et***

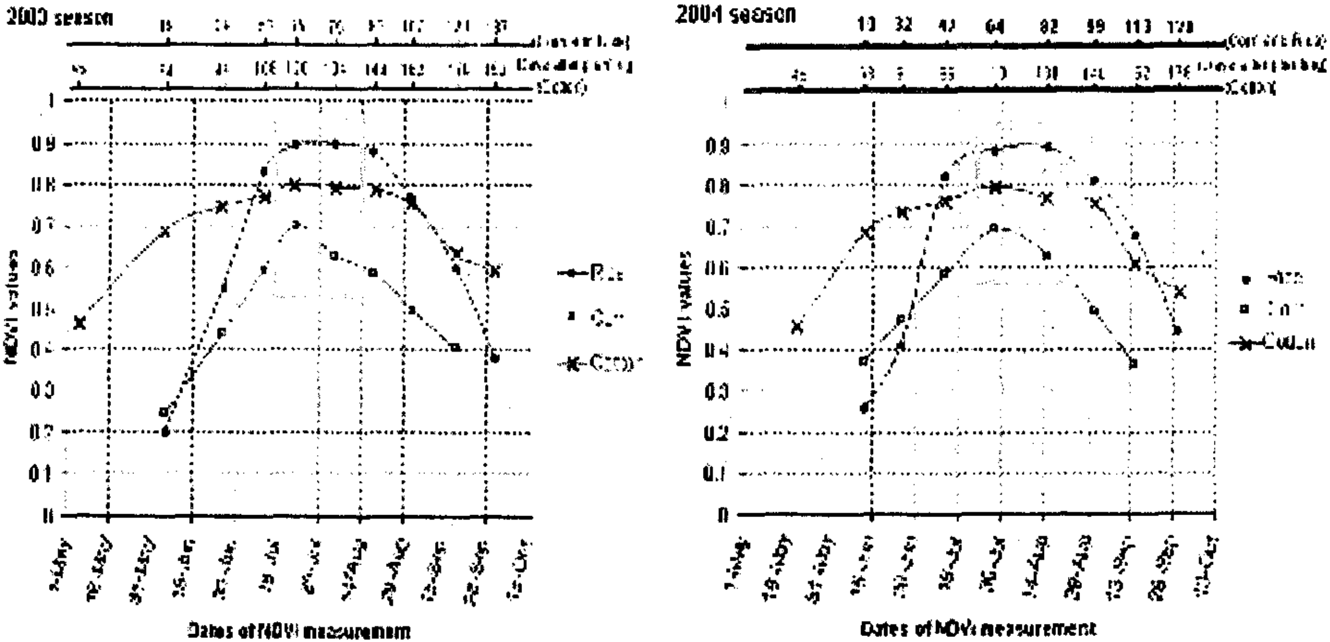


Fig. (1), NDVI changes throughout the growing season for corn, cotton and rice (2003&2004). (Source Al-Khaled, *et al* 2005)

Table 3. Simple correlation between spectral reflectance & NDVI and economic yield of cotton, corn and rice in 2003 and 2004 seasons.

Reflectance / Crops	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	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					2004		
			Stage 2					Stage 2		
Cotton	.129	.040	-.466	.149	.688**	-.157	-.040	-.271	.263	.520*
corn	-.793**	-.419	-.215	.484	.473	-.185	-.370	-.149	-.055	.039
			Stage 3					Stage 3		
Cotton	-.758**	-.668**	-.827**	-.435	.702**	-.799**	-.877**	-.724**	.144	.776**
corn	-.603*	-.648**	-.091	.511*	.636**	-.549*	-.672**	-.323	.517*	.631**
Rice	.151	-.073	-.113	.024	.097	-.470	-.390	-.404	-.635**	-.386
			Stage 4					Stage 4		
Cotton	-.651**	-.570*	-.607*	.134	.805**	-.960**	-.937**	-.634**	.335	.727**
corn	-.466	-.492	.335	.638**	.779**	-.662**	-.679**	.197	.547*	.733**
Rice	-.916**	-.923**	-.868**	.225	.652**	-.535	-.605	-.509	.195	.507
			Stage 5					Stage 5		
Cotton	-.926**	-.873**	-.896**	.572*	.882**	-.889**	-.841**	-.853**	.884**	.958**
corn	-.839**	-.684**	-.631**	.478	.799**	-.827**	-.901**	-.845**	-.128	.878**
Rice	-.813**	-.880**	-.365	.530*	.794**	-.690	-.752*	-.718*	-.154	.850**
			Stage 6					Stage 6		
Cotton	-.840**	-.911**	-.804**	.936**	.957**	-.736**	-.731**	-.685**	.637**	.611*
corn	-.557*	-.438	-.187	.504*	.747**	-.819**	-.801**	-.390	.204	.707**
Rice	-.864**	-.857**	-.839**	.212	.801**	-.483	-.176	-.938**	-.349	.769*
			Stage 7					Stage7		
Cotton	-.634**	-.891**	-.448	.816**	.694**	-.598*	-.612*	-.442	.397	.668**
corn	-.635**	-.598*	-.262	.377	.788**	-.640**	-.807**	-.274	.110	.589*
Rice	-.950**	-.911**	-.790**	.442	.639**	-.910**	-.752*	-.514	.267	.757*
			Stage 8					Stage 8		
Cotton	-.621*	-.626**	-.341	.116	.550*	-.614*	-.791**	-.287	.169	.559*
Corn	-.548*	.185	.103	.429	.451					
Rice	-.051	.105	-.120	.675**	.491	-.728*	-.726*	-.699	.333	.623

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

al 2004) and seed cotton yield (**Perumal** ***et al*** **1999**) and grain yield of rice (**Quarmby,** ***et al*** **1993**).

C- Yield prediction

Generally, knowledge of the phenological events of crops are important in determining the better period over which the economic yield should be predicted, depending upon NDVI values. The approximate periods that correspond to the phenological stages of stage 5 and 6 were selected for crops study. With respect to the data in Table (2) the NDVI values registered magnitude values at the aforementioned phenological stages; also, Table (3) showed highly significant correlation coefficients between seed cotton yield and grain yield of corn and rice with NDVI values at aforementioned phenological stages. To predict economic yield, the linear regression was computed between economic yield production (seed cotton and grain for corn and rice) and NDVI values summed at stages 5 and 6 in 2003 and 2004 seasons. The linear regression models that may describe such relationship at stages 5 and 6 for cotton, corn and rice are as follow:

Seed cotton yield (Ton/fed) = 1.5378 [NDVI] – 0.3027 (cotton)

Grain yield (Ton/fed) = 8.3288 [NDVI] – 0.0458 (corn)

Grain yield (Ton/fed) = 18.998 [NDVI] – 13.106 (rice)

Figure (2), shows that seed cotton, corn grain and rice grain yield increased linearly as NDVI values increased. The yield response was significant at the p = 0.01 level (r^2 = 0.6162**, 0.3913** and 0.5467** for cotton, corn and rice, respectively).

Finally, obtained results showed the potential for using the NDVI parameter derived from field hand held radiometer (SE 590) or Landsat satellite (TM) data in seed cotton yield and grain yield estimates.

2- Analysis of remote sensing data

A- Crop area estimation

Estimating the cultivated area is the primary step for crop yield forecasting, this estimation is usually necessary to calculate crop planting area in a particular administrative division for the purpose of being in agreement with the existing statistical channels.

1- Image processing

Image classification is the process of assigning classes to the pixels in a remotely sensed image and generating a thematic or land cover class map. Thus, a classified image shows the spatial distribution of a particular theme or class of interest. In general, classification procedures have been grouped into two classes: supervised and unsupervised. In a supervised classification, training pixels or areas are selected for each category, based on some prior or acquired knowledge of the classes in the imagery, and the image is then segmented according to spectrally "similar" pixels for each class.

An image of rectified images of multispectral LANDSAT-7 ETM+ path 177/row 39 acquired on 24 July 2004 was prepared to be used in supervised classification process. Area of study was extracted from this image. This process aims to classify all the image pixels in different signatures as well as classes. In this

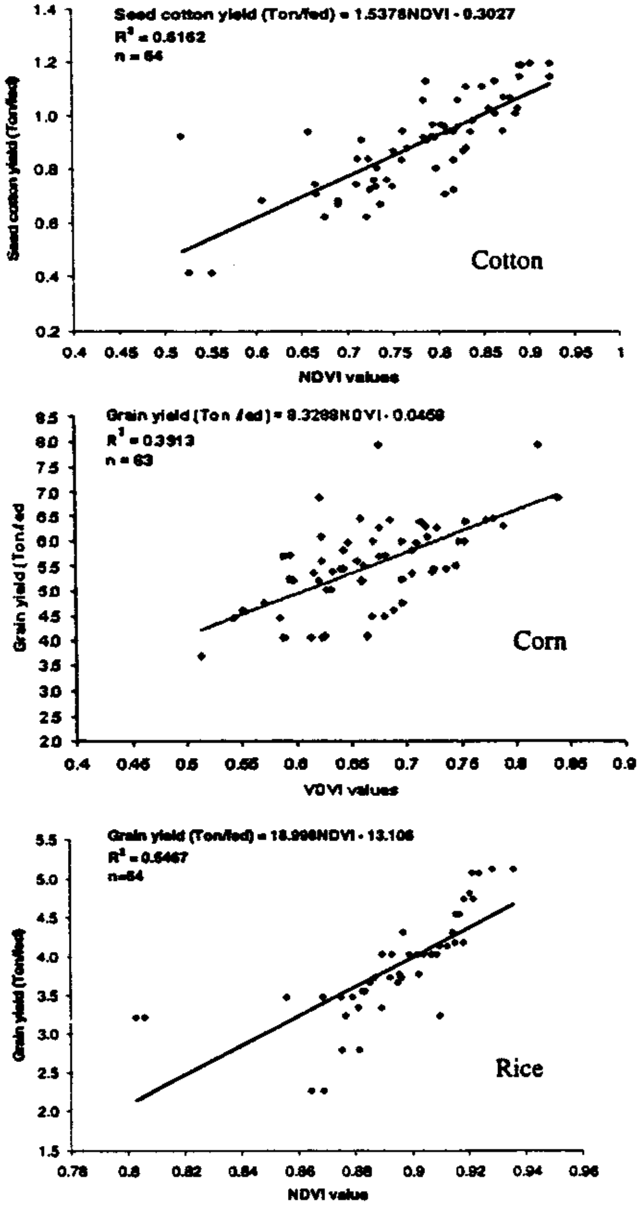


Fig. 2. Economic yield and NDVI relationship for cotton, corn and rice at stage 5 and 6 in 2003 and 2004 seasons

investigation the pixels of image were classified into 6 categories namely (rice, corn, other crops, urban, water, and others), and depending on their spectral signatures.

The process of image classification was done as fallows:

2-1- Training area

The image of ElKanater ElKhayrya district (step 4) was used to generate supervised signatures using the Area of Interest AOI tools by delineates training areas. This process considers input data stage for supervised classification process and it depends on the reflectance value of surface. In field work, it was noted that the planting area of cotton crop was rarely in the study area, whereas corn crop constitutes the majority of the study area followed by rice crop. These measurements were very important in delineating process for training areas to be located in its exactly locations. Signatures data express on one class.

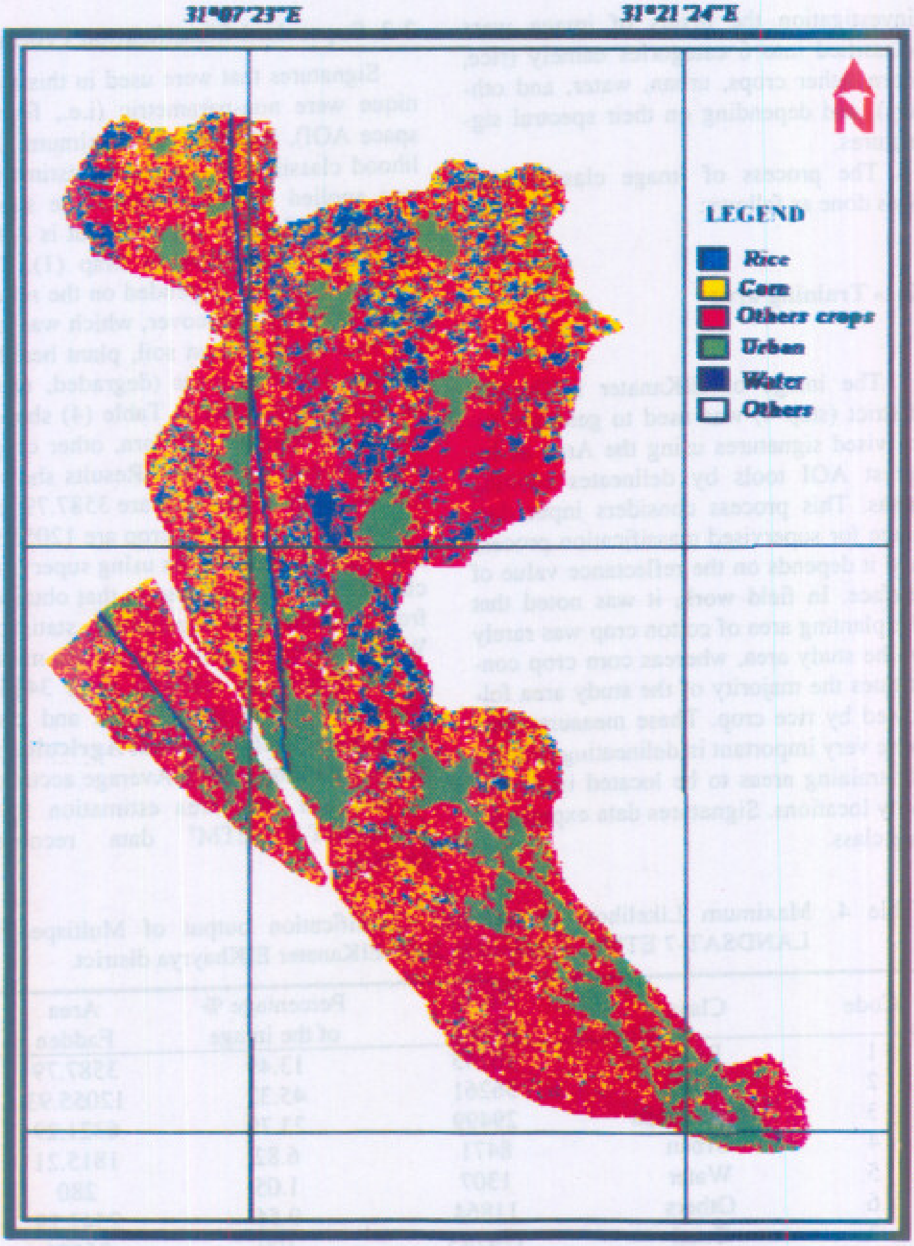
2-2- Supervised Classification Process

Signatures that were used in this technique were non-parametric (i.e., feature space AOI), therefore the maximum likelihood classifier for crop area estimation was applied in this process. The supervised classification utility output is a thematic layer as shown in Map (1). The classified classes depended on the reflectance of the ground cover, which was taking into consideration soil, plant healthy, change detection areas (degraded, urban or agriculture). Data in Table (4) show 6 classes as follow: rice, corn, other crops, urban, water, and others. Results showed that the areas of rice crop are 3587.79 fed. While the areas of corn crop are 12055.93 fed. The calculated areas using supervised classification were closed to that obtained from ministry of agriculture statistics. Where, the calculated areas by the ministry of agriculture statistics were 3416.4 fed and 11456.8 fed for rice and corn crop, respectively **(Central Agricultural Administration 2004)***. Average accuracy of rice and corn area estimation from LANDSAT-7 ETM$^+$ data recorded 88.68%.

Table 4. Maximum Likelihood Supervised Classification output of Multispectral LANDSAT-7 ETM+ Acquired in 2004 ElKanater ElKhayrya district.

Code	Class	No. of Pixels	Percentage % of the image	Area Fadden
1	Rice	16743	13.49	3587.79
2	Corn	56261	45.32	12055.93
3	Others crops	29499	23.79	6321.29
4	Urban	8471	6.82	1815.21
5	Water	1307	1.05	280
6	Others	11864	9.56	2542.29
7	Total	124145	100	26604

* Personal communications with central Agricultural Administration in El-Kanater El-Khayriya district, Ministry of Agriculture and Soil Reclamation, Cairo.



Map. 1. Maximum Likelihood Supervised Classification output of Multispectral LANDSAT-7 ETM+ Acquired in 2004 ElKanater ElKhayriya district.

B- Forecasting crop production

In crop production estimation using remotely sensed data, it is necessary to estimate crop area and yield per unit area in a particular administrative division. Estimating and forecasting the productivity of rice and corn from ETM^+ satellite image data of ElKanater ElKhayrya district may be calculated by the equation for each crop:

PF = CPA X YP

Where is, **PF** : Productivity forecasting of the study area (Ton)

CPA: Crop planting area in the study area (fed) is calculated as follow:

CPA = (NP X AP) / AF

Where is, NP: Number of pixels in the image.

AP: Area of pixel (m^2). Usually, area of pixel is different with the differentiation in satellite image. In LANDSAT multispectral data of the area of pixel equals 30*30 =900 m^2.

AF: Area of feddan = 4200 m^2.

YP: Yield predication in feddan (Ton/fed) is depending on crop species, and it is derived depending upon NDVI values and their relations with crop yield at stages 5 and 6 for rice and corn (mid July to mid August). Yield predication equations for corn and rice are mentioned before (Fig. 2) as follow:

Grain yield (Ton/fed) = 8.3288 [NDVI] – 0.0458 [Corn]

Grain yield (Ton/fed)= 18.998 [NDVI] – 13.106 [Rice]

Now when the previous equations were applied to forecast yield productivity of the study area (ElKanater ElKhayrya district) for rice and corn crops, then

1- Rice *PF = CPA X YP*

Where CPA is calculated as follow:

CPA = (NP X AP) / AF

NP = 16743 is taken from Table (4),

AP = 900m^2, AF = 4200m^2

CPA= (16743 X 900)/4200= 3587.79 (fed)

While, ***YP for rice =***

18.998[NDVI]– 13.106

NDVI = 0.888 considering that this value is representing the average of NDVI values in the stages 5 and 6 during 2004 season (Table,2).

YP =18.998 [0.888] – 13.106 = 3.76 **(Ton/fed)**

Then **PF = 3587.79 X 3.76 = 13490.09 (Ton).**

The same steps were applied on corn crop and it was found that **PF = 65584.56** (Ton). These values are representing the productivity of rice and corn crops on the level of the study area (ElKanater ElKhayrya district).

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مجلة حوليات العلوم الزراعية، كلية الزراعة ، جامعة عين شمس ، القاهرة ، م(٥٠)، ع (٢)، ٤٨١-٤٩٨، ٢٠٠٥

تقدير المساحة المنزرعة لبعض محاصيل الحقل الصيفية والتنبؤ بانتاجيتها 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 و٢٠٠٤ لدراسة الصفات الانعكاسية لأهم محاصيل الحقل الصيفية وهي الذرة والقطن و الأرز بواسطة السبيكتروميتر SE590 و حساب الدليل الطبيعي للاختلافات الخضرية NDVI عند مراحل النمو المختلفة لهذه المحاصيل، وذلك بهدف معرفة امكانية تمييز هذه المحاصيل بالاعتماد على قيم الـ NDVI والتنبؤ بغلتها اعتمادا على العلاقة بين قيم الـ NDVI والغلة . واعتمادا على فترة التمييز المتوصل إليها من التجربة الحقلية تم الحصول على بيانات الأقمار الصناعية لمنطقة الدراسة المختارة (مركز القناطر الخيرية) في فترة ٢٠٠٤/٧/٢٤ بعرض حصر المساحات لكل محصول في منطقة لدراسة نتيجة لمعالجة هذه البيانات وتحديد مساحاتها ومن ثمة العمل على تطبيق معادلات التنبؤ للغلة التي تم التوصل إليها من التجربة الحقلية على البيانات الفضائية المستقدمة وتوقع كمية المحصول لكل من الأرز والذرة لمنطقة الدراسة (مركز القناطر الخيرية). ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي

لوحظ وجود فروق معنوية بين قيم الـ 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 الـ NDVI في مرحلة النمو الأعظم والتي توافق الفترة الواقعة ما بين منتصف يوليو إلى منتصف أغسطس تقريباً في ظل ظروف

التجربة المقامة. أظهرت العلاقة ما بين الدليل الطبيعي للاختلافات الخضرية NDVI والمحصول أن هناك ارتباط مرتفع المعنوية بين الدليل الطبيعي للاختلافات الخضرية NDVI والمحصول عند المرحلة الخامسة والسادسة من عمر النبات في كلا موسمي النمو لمحاصيل القطن والذرة والأرز والواقعة بين منتصف يوليو إلى منتصف أغسطس. أظهر معادلات الانحدار الخطي وجود علاقة مرتفعة المعنوية بين الدليل الطبيعي للاختلافات الخضرية (NDVI) وكمية المحصول الاقتصادي عند مرحلتي الخامسة والسادسة من تطور النبات والواقعة بين منتصف يوليو إلى منتصف أغسطس مما أدى إلى التنبؤ بكمية المحصول بالاعتماد على قيم الدليل الطبيعي للاختلافات الخضرية (NDVI) عند المرحلتين السابقتين.

تم حصر مساحة المحاصيل في منطقة الدراسة (مركز القناطر الخيرية) اعتماداً على تحليل الصورة الفضائية ونتائج عملية التصنيف المراقب supervised classification فكانت المساحة المنزرعة من محصول الأرز تساوي ٣٥٨٧,٧٩ فدان ومن محصول الذرة ١٢٠٥٥,٩٣ فدان. بلغت درجة الدقة في تصنيف وحصر مساحات محصولي الذرة و الأرز خلال عملية معالجة الصورة الفضائية لمنطقة الدراسة ٨٨,٦٨ %. تم التنبؤ المبكر بانتاجية محصولي الذرة والأرز للمنطقة المدروسة من خلال سلسلة من العلاقات الموضوعة لهذا الغرض من خلال الدمج بين معادلات التنبؤ التي تم التوصل إليها باستخدام أجهزة القياس الطيفي الأرضية والمحمولة وتمييز المحاصيل في المنطقة المدروسة وتحديد مساحتها نتيجة لتحليل الصورة الفضائية. وعند تطبيق هذه المعادلات للتنبؤ المبكر بغلة محصولي الأرز والذرة على نطاق مركز القناطر الخيرية التابع لمحافظة القليوبية في الموسم الزراعي ٢٠٠٤، وجد أن انتاجية الأرز كانت ١٣٤٩٠,٠٩ طن وأن انتاجية الذرة كانت ٦٥٥٨٤,٥٦ طن.

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