Advances in Scientific Research: Engineering and Architecture

Editors

Ilia CHRISTOV
Viliyan KRYSTEV
Recep EFE
Abd Alla GAD

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Towards a development of Spectral Signature database supporting soil and vegetation cover assessment, based on Egyptian case studies

Abd Alla GAD and Ghada KHDERY

National Authority for Remote Sensing and Space Sciences, Egypt

Introduction

The term "Spectral signature" refers to the radiometric feature, resulted due to the presence or absence of different surface absorption features, as well as location and form. Figure 1 illustrates an example of Vegetation Reflectance Curve, considered as spectral signatures for the plant. Each of other material and vegetation type is characterized by a unique spectral signature, as shown in Figure 3.

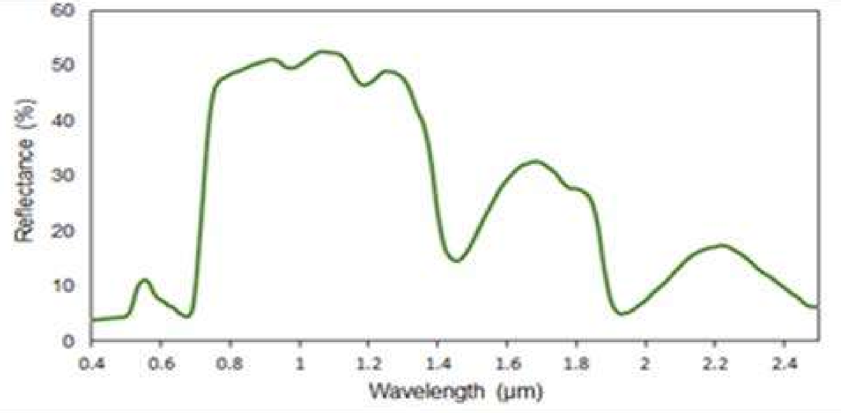

Figure 1. Vegetation Reflectance Curve, considered as spectral signatures for the plant

The aims of the analysis, at First of all, concern checking the relationship between soil physical and chemical characteristics, in one hand and spectral reaction in the other hand. It is also aimed to test the relation between plant species and status, on one hand, and spectral radiometric behavior of plant sectors, on other hand. If such relation is confirmed, it would be worthy to call for developing soils and plant signatures database to support intensive survey needed in persecution farming and assist image processing.The Management processes of an agricultural systems depend on the success in production cost control and capability to increase productivity. Varity of analyses are needed to be elaborated and understood to obtain a better agriculture outcome response from same inputs (van Vuuren et al., 2006). The combined Visual and Near Infra-Red (VIS-NIR) technology has the potentiality to detect fine-scale spatial variability of soil. Moreover, results sound to be very accurate according to Viscarra Rossel and McBratney (2008). The same technology has been used in assessing grain, fertilizers and soil qualities, where results confirmed the rapidness, convenience to analyze many soil constituents at the same time (Ben-Dor and Banin, 1995; Faraji et al., 2004; Mohan et al., 2005). The optimized VIS-NIRS soil properties include determination of soil moisture, soil organic carbon content (SOC), electrical conductivity (EC), cation exchange efficient Capacity (CEC), soil acidity, other macro and microelements (Dunn et al., 2002; Velasquez et al., 2005). Absorption in the near-infrared spectral region (780.2500 nm) is dominated by molecules that contain strong bonds between light atoms. Specifically, these are molecules that contain C-H, N-H or O-H bonds. This fact confirms that the near infrared region is specifically useful for measuring forms of carbon, nitrogen and water, in a rapid and non-destructive analytical tool (Chang and Laird, 2002).

1. Needs for frequent soil and vegetation monitoring

The cultivable soil is a rather important element in agriculture sustainability. The equilibrium character of soil state with surrounding conditions interprets the soil dynamic nature. For instance, ground water level changes have its impact on the soil salinity hence on growing vegetation type and status.

The success of agricultural sustainability depends on the permanent control on soil conservation and plant protection against diseases and nutrients deficiency. Different soil analyses processes are needed to be carried out, along crop production periods. Such continued monitoring allows to find out, in the right time, best inputs that can be applied for better proposed outcomes (van Vuuren et al., 2006). VIS-NIRS technology has the capability to detect spatial variations of soil at a fine scale. In addition, the findings can be very precise, as seen in their analysis by Viscarra Rossel and

McBratney (2008). Unfortunately, a change in mindset is required from the traditional soil and planting approach to the adoption of the VIS-NIRS system for precision agriculture, as van Vuuren et al. (2006) emphasized. AI-Abed, Samson and Lewis (1989) concluded that Precision farming, intensive data is collected to proceed with agricultural system activities. It is important to collect data resources capable of collecting reliable information on the field to support management decisions. Image processing techniques are one of the difficult methods that can be used to collect information on field conditions.

2.Recent soil and vegetation monitoring technologies

Coincidence and utilization of vast progress in scientific technologies are rather advantageous. For conserving all-natural terrestrial resources. Soil Survey is one of the services, within the NRCS. It provides technical assistance to help human being preserve, improve, and maintain their natural resources and climate.

It should be highlighted that the main soil survey purpose and logic continue to be constant, however, the soil surveyor's ability to record, assemble, and present information has progressed. The major Such continuous soil data updates enables land managers to best manage natural resources. As soil moisture monitoring is the key to ensuring good irrigation management decisions soil scout is a recent developed good sensor example that enable land use related water and energy optimization in an exceptional detail and ease by providing a future-proof below-ground monitoring system. It provides the only wireless sensors capable of transmitting moisture, temperature and salinity data in near real-time out-of-sight performance from up to 2 meters / 6 feet below the surface. Understanding what's happening below the soil surface is critical for many industries. Soil Scout takes monitoring to the next level by providing a detailed view into in-field variation, enabling our customers to expand the Precision Agriculture approach to all land use challenges, be that smart farming, irrigation control or turf quality optimization. Soil Scout provides critical insight into data from deep below the surface wirelessly, enabling 365x24 insight and profiling which allows end user to perform better, understand their operations deeper and reduce water and energy use by up to 50%.

3.Spectroradiometers Instrument

The technical market offers both types of spectroradiometers, a portable one equipped for Field measurements and other for laboratory ones. They are available from 300 to 1000 nm in three wavelength ranges (Fig. 2). Portable Spectroradiometer is used for field measurements as well as laboratory measurements in three wavelength ranges from 340 to 1100 nm. Measurement of the spectral production (energy flux intensity, photon flux density or luminance of various radiation sources (often for plant, soil or human lighting), and reflectance and transmission measurements of natural and synthetic surfaces and materials (often plant Lab Spectroradiometers and canopies).

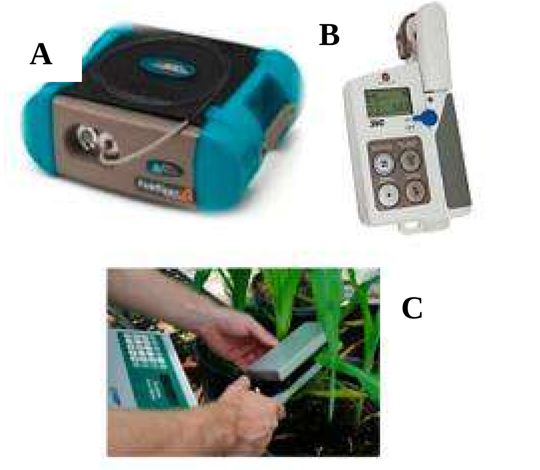

Figure 2: Hand held Spectroradiometer Devices for collecting crop related information (A) Spectroradiometer, (B) SPAD 502, and (C) leaf area meter

4.Spectro-Radiometric measurement for soils and vegetation

Spectro-Radiometry is the spectral reflectance generated values, generated by the presence or absence, the location and shape of a particular material. Absorption characteristics “Signature of a material” is a Spectral Reflectance Curve. Such curve displays light reflectance from a surface within a wavelength range, such as paper. In the visible spectrum, as a way of determining the colour of the product as seen in figure (3) for soils, waste, and vegetation. Light absorption by leaf pigments dominates the reflectance spectrum in the visible region (400–700 nm) with respect to the vegetation. For photosynthesis, chlorophyll pigments a and b selectively absorb wavelengths of blue (400–500 nm) and red (600–700 nm). Less absorption over the "gray" wavelengths (500–600 nm) results in clear green appearance of good flora. In addition to the red and blue pigment, xanthophyll, the carotene portion, characterized by a yellow to orange-red pigment, causes strong absorption in the blue wavelengths (400–500 nm). Stressed vegetation blocks off a different spectral signature which correlates with the stress effect on the different pigments of the leaves. In comparison, wavelengths near-infrared (700–1300 nm) are transmitted and reflected, dependent on leaf structural characteristics, which results in a high near-infrared (NIR) plateau, depending on the structural features of the leaf. The sharp rise in reflection between red and NIR regions is known as the red edge and is used in the identification of plant stress. The Middle Infrared (MIR) region (1300–2500 nm) is dominated by soil and leaf water absorption, particularly at 1400 and 1900 nm with the reflectance; When the water content of liquid leaves decreases (see Figure 3).

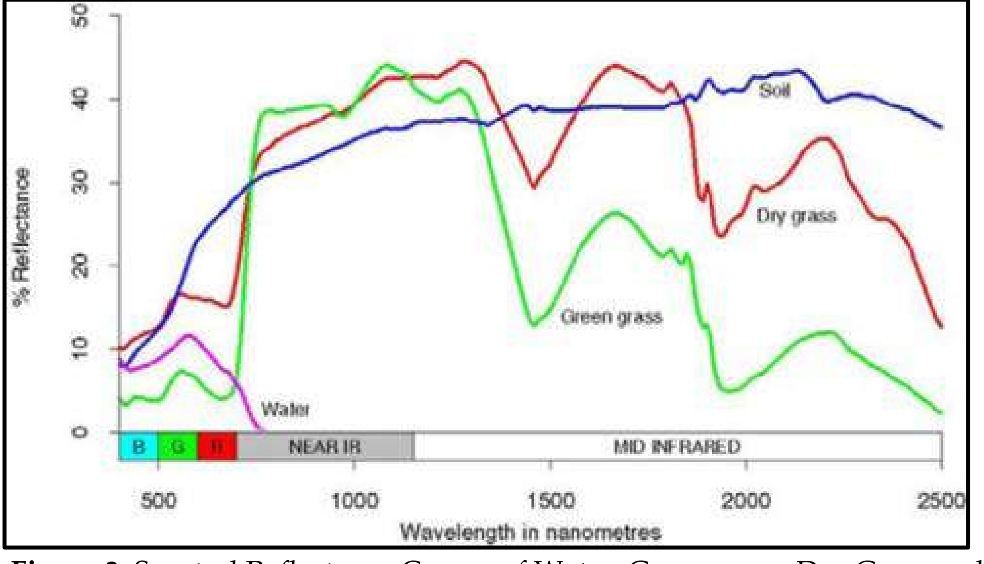

Figure 3: Spectral Reflectance Curves of Water, Green grass, Dry Grass and Soil surfaces.

The new approach sounding in soil sampling is the need for real time continuous soil monitoring. Such approach is generated by the precision farming to endorse the decision support, where extensive accurate data are used in the practice of the agricultural system. Early attempts involving spectroradometer in soil survey were to detect imaged soil and soil reflectance of textural features. The purpose was to create a correction factor to determine the soil parameters using the soil spectrophotometer in real time and to investigate the probability of using the textural image features to predict soil humidity in both surface and surface horizons. The soil spectrophotometer approach, as a real time information gathering tool, has been developed and tested both in field and laboratory (Shibusawa *et al.*, 1999, 2000; I Made, Anom *et al.., 2000a;* 2000b; 2001). The results show a very law prediction accuracy, in case original reflectance data were used without any pretreatments. Applying pretreatments on reflectance values lead to increase the prediction accuracy, Moreover, it is recently realized that prediction of soil parameters changed with time and form of soil. Many attempts have been made to improve the accuracy and repeatability of the predictive models, such as observing the influence of the surface angle, surface condition and surface temperature on soil absorbance (Sato 2001). This was shown by the study that was made in the laboratory. The surface condition greatly affected soil reflectance; however, further observations are still needed to find out the surface condition role on soil reflection. The textural image analysis is applied in these experiments to search that soil surface condition effect on soil reflectance. A link between the textural characteristics of soil image and reflection have been used to assess the soil parameters, using a real time soil spectrophotometer values and to analyses the likelihood of use, predict soil humidity content and other underground soil parameters.

5. Case Study: Spectral signature of Alluvial Nile soils, Al- Baheria governorate, Egypt

5.1. General

The case study is one of the early attempts to investigate the hyperspectral characteristics of alluvial soils of Nile Delta, in relation with plant species and status, at Al Baheria governorate, Egypt. Finding such relation would support the hypothesis relating object characteristics and spectral signatures. The results also assist to understand the vegetation structure responding to growth environment, including water and soil characteristics. Spectral reflectance of plants and soil surfaces were recorded, using ASD field Spec, Various hyperspectral indices for collected representative soil surface sites and associated plant covers. First the optimal waveband was chosen then the optimal wavelength to differentiate the taxa studied using ANOVA analysis.

Al-Beheira Governorate is one of the most important Governorates in Egypt, Located in the Apartment north Delta region south of Alexandria. It is administratively sub-divided into 13 administrative districts or Markaz. Kowm Hamadah and Abu Al-Matamir are the largest two districts in the Governorate, covering 1683.5 and 1278.6 km^2, representing 26.4% and 20.1% of the total area respectively. Gad (2011) referred, on bases of a developed land resources database (Figure 4) that the medium size districts are located in the alluvial landscape area (i.e. Kafr Al–Dawar, Abu Homos and Damanhour) ranging between 582.4 km^2 and 389.9 km^2, representing 9.1% to

6.1% respectively.

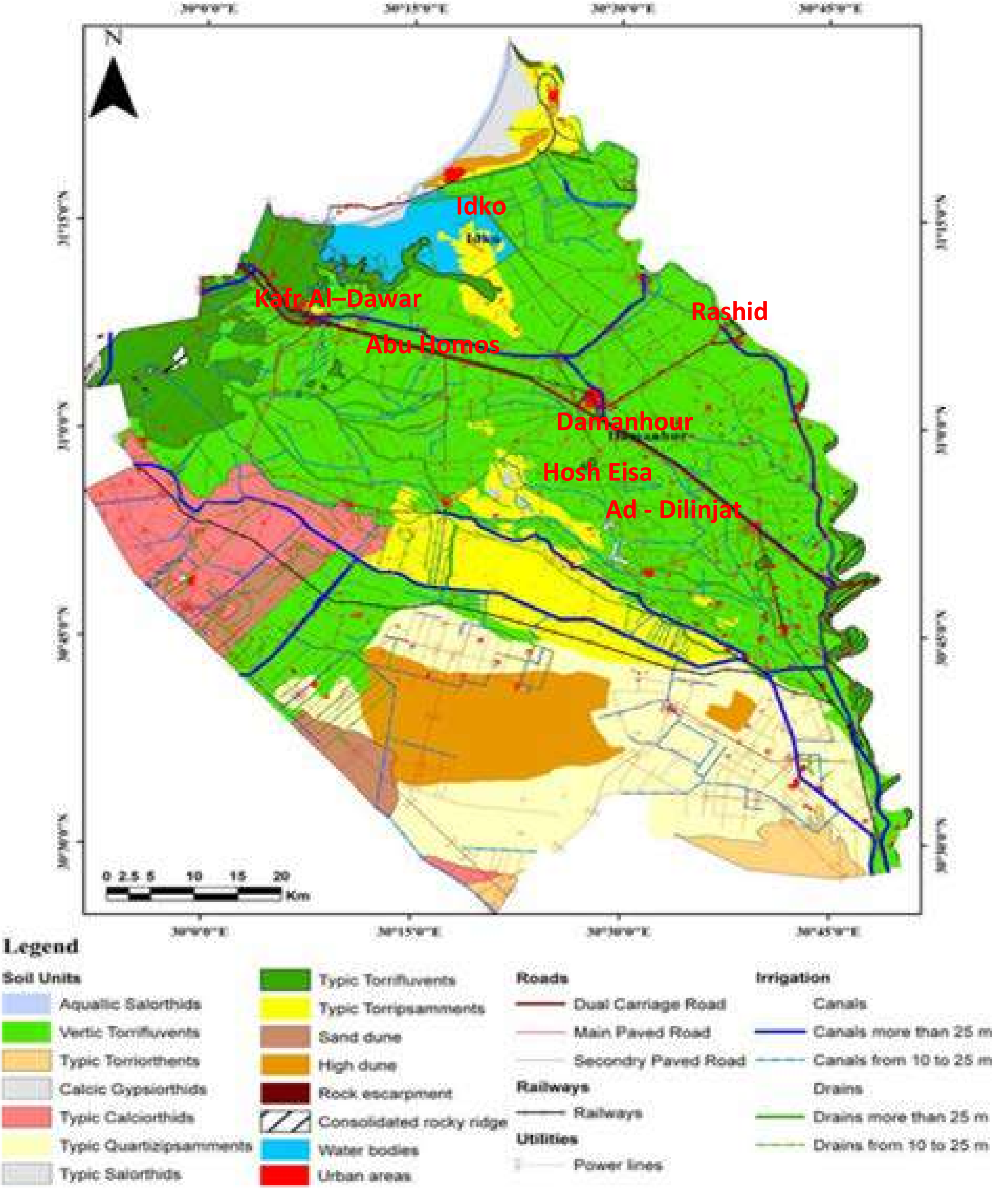

Figure 4: Main soil conditions included in the database of Al-Beheira Governorate
(Cited from Gad, 2011)

The other districts (i.e. Rashid, Idko, Al-Mahmoideyah, Al-Rahmaneyah, Shubrakhit, Hosh Eisa, Itay Al-Baroud and Ad-Dilinjat) cover relatively small areas. Their areas range between 379.9 km^2 in Al- Dilinjat and 197.7 km^2 in Rashid district representing 5.9% and 3.1% respectively.

The study area, Al-Beheira governorate, is located in the northern Nile Delta coast of Egypt. Its capital is the city of Damanhur. The name "Al-Beheira" means 'the Lake' in Arabic, and true to its namesake, the governorate is home to many water bodies of the Delta region. This governorate is particularly important because of the city of Rosetta, which is one of the most important port cities in Egypt. El-Beheira governorate is not a highly-populated region, and is rich in the cultivation of cotton, potato, and dates; giving rise to the related industries of potato processing, picking dates and cotton textile industry.

The soil map Displays the distribution of different subgroups of soil, where the *Vertic Torrifluvents,* characterized by fine texture ranging from clay to clay loam, is dominating the soil types and It is concentrated in the alluvial region. It occupies an area of 3026.2 km^2, accounting for 47.8 % of the land. The Traditional *Torripsamments* and Typic *Torrifluvents* sub-great classes conflict with the previous one within the 550.0 km^2 and 428.8 km^2 alluvial landscapes covering 8.7 % and 6.8 % respectively. The *Typic Haplocalsids* subgroup protects important areas around Idko and Mariout lakes, with a total of 536.7 km^2 representing 8.5% of total Governorate.

Limited patches of sub-great groups *Typic Aquisalids, Typic Haplosalids and Typic Calcigypsids* soil interfere with *Typic Haplocalsids* soils covering an areas of 28.0, 72.3 and 1.8 km^2 representing 0.4%, 1.1% and 0.03% respectively. These soils are characterized by medium to fine texture and possibility of salinization and water logging

The *Typic Quartizpsamments* sub-great group, characterized by coarse sandy texture covering An region of 994,4 km^2 (15% of the soil) situated in the south-western part of the Governorate, adjacent to sand dune areas. It is also interfered by the *Typic Torriorthents* sub-great group, covering small patches having an area of improved product km^2 representing 1.7 % of total soil area.

Table 1. Areas and frequencies of different soil types, Al-Beheira

Governorate

Type (Sub great group)	Area (Km^2)	%
Typic Aquisalids	28.0	0.4
Typic Calcigypsids	1.8	0.03
Typic Haplocalsids	536.7	8.5
Typic Quartizpsamments	994.4	15.7
Typic Haplosalids	72.3	1.1
Typic Torrifluvents	428.8	6.8
Typic Torriorthents	107.3	1.7
Typic Torripsamments	550.0	8.7
Vertic Torrifluvents	3026.2	47.8
Consolidated rocky ridge	7.8	0.1
High dune	430.9	6.8
Sand dune	149.7	2.4
Total	6333.9	100.0

The field and lab investigated area, in current study, was selected at the northwest of the governorate (Figures 5 and 6) representing common soil classes and plant species, found in AL-Bhaira governorate, demonstrated in table (1). Enhanced classified satellite images and thematic maps were utilised to correct the data geometrically. Field validation was practiced to collect ground control points, in addition to digging and describe soil profiles with collection of representative soil and vegetation **cover** samples for measuring the spectroscopy. Also growth conditions and environment were observed and recorded to find its impact on spectral values of soil. In case that a relation is confirmed, thus growth environmental conditions can be predicted and decision support maybe achieved via spectral characterization curves, integrating remote sensing technologies will be value added and may be utilized for early detection of vegetation stress.

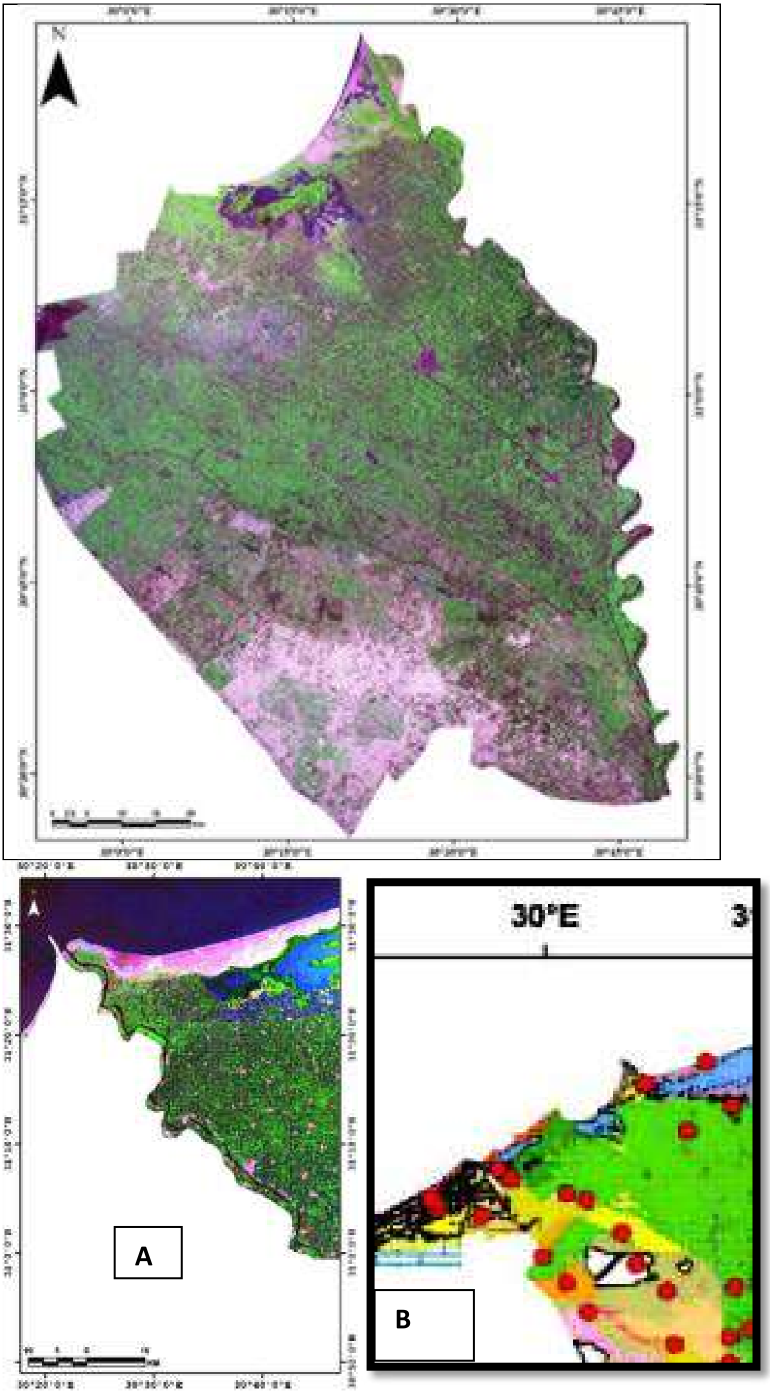

Figure 5. Landsat satellite image shows variability of vegetation cover types at Al-Beheira Governorate

5.2. Spectral characterization of soil conditions

The soil characterization Showed that changes in the reflectance and form of the spectral curves can be due to soil texture differences. The accepted correlation between the shape of NIR spectra and the soil texture agrees with the same truth (Mouazen 2005). In figure, mean spectral curves of different classes of soil texture are shown. Figure 6 concerns loamy sand textured soils, including > 70 % sand content, demonstrates relatively high reflectance. This reflection pattern is most probably due to the significant inclusion of quartz in the sand fraction, which raised the intensity of spectral reflectance (Webster 2007). The fine soil particles (I,e, Leather fraction) lead to the observed lower soil reflectance decreased when clay content dominated from phyllosilicates increased (Palacios 1998) and thus the organic carbon content increased. In general, soil reflectance was found to be relatively low in the Vis-NIR spectral domain, due to the high content of organic carbon.

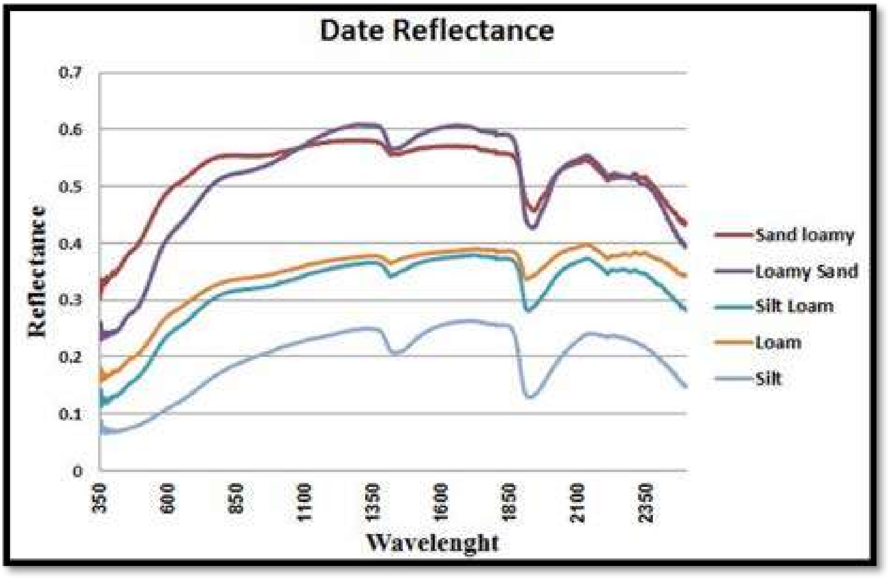

Figure 6: Spectral signature for soil of variable texture, Al-Baheria governorate, Egypt.

5.3. Spectral characterization of vegetation types and status

The results showed that healthy cultivated plants induce higher reflectance values, in visible spectral bands, than infected ones, however healthy plants showed comparative higher reflectance throughout the whole spectrum. While all spectral zones, except short wave Infra-Red (SWIR), were effective to differentiate between healthy plants and infected ones, blue and the red spectral zones were ideal for such differentiation. Hyperspectral technology can play a major role in the spectroscopic characterization and spectral identification of plant species found in Egyptian wadies and deserts, especially those of high medical value. It proved excellent capacity in identifying effective spectral areas for the classification and conservation of these species.

6.Case Study Differentiation between different wild plants in North west coast of Egypt with GPS locations

6.1. General

The selected case study area is located at the Egyptian north western coast that extends from Eldabaa area in the east to the west of Fuka (30° 28' 57.99" to 31° 41' 32.01" North) and from (26° 33' 35.36" to 28° 21' 25.41" East). The study case area (Figure 7) belongs administratively to the governorate of Matrouh with a total surface area of 17019 km².

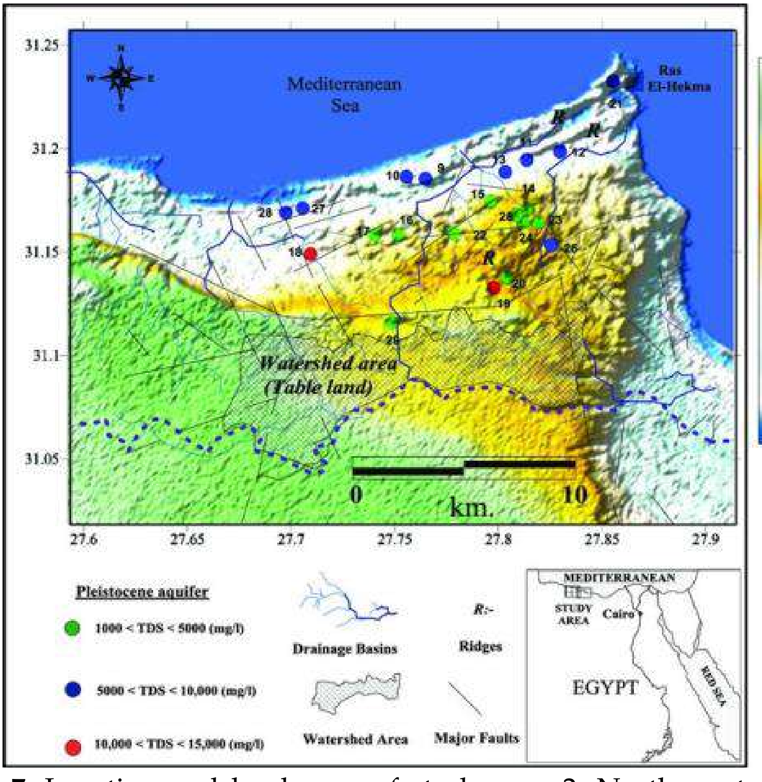

Figure 7. Location and landscape of study case 2. North-western coast of Egypt

The case study of a coastal region is characterized by a humid climate, where average temperature for the air is 15 °C during the survey period in December 2018. The mean rainfall is around 11.42 mm.

Comprehensive survey of the vegetation was carried out. , where representative samples of common plants species were collected and identified (Table 2) according to (Tackholm, 1974; Boulos, 1995, 1999, 2000, 2002 and 2009).

Table 2. Geographic Location of studied wild plants at study case North-western coast of Egypt

Plant Name- Habit	Latitude (N)	Longitude (E)	؛Plant Location
Zygophyllum album	30 ؛ 50' 37.14''	28؛ 55' 58.44''	Road sides
Echinops spinossissimus	30 ؛ 47' 37.5''	28؛ 58' 48.84''	Non-saline depressions
Dabaa Transect			
Zilla spinosa	31º 03' 41.16''	28º 12' 31.62''	Cave mouth
Atriplex halimus	31º 04' 00.66''	28º 20' 05.52''	Coastal sand dunes
Matruh Wadis			
Phlomis floccosa	31º 21' 44.82''	27 º 59' 31.02''	Wadi bed
Teucrium polium	31º 23' 42.48''	27 º 01' 37.08''	Wadi bed
Peganum harmala	31º 21' 54.90''	27 º 03' 07.56''	Wadi slope
Maktala Transect			
Urginea maritima	31º 30' 48.00''	26º 12' 06.66''	Sand flats
Barrani Transect			
Arisarum vulgare	31º 36' 31.74''	25º 48' 30.78''	Sand dunes
Thymelaea hirsuta	31º 36' 32.36''	25º 48' 28.22''	Wadi beds
Sallum Transect			
Globularia arabica	31º 28' 50.22''	25º 15' 57.20''	Road sides
Limonium tubiflorum	31º 30' 06.72''	25º 18' 41.04''	Saline depressions

6.2. Defining plants optimum waveband zones

Spectral reflectance of the wild plants has been measured by spectroradiometer for the analytical field (ASD field spec). The spectral reflectance may be divided as follows into six spectral zones: blue (350-440 nm), green (450-540 nm), red (550-750 nm), NIR (760-1000 nm), SWIR I (1010-1775 nm), and SWIR II (2055-2315 nm).

The wavelength generated by hyper spectral techniques can be regarded as fingerprints in terms of number and location, as useful and efficient tools for identifying the samples studied. It was possible to distinguish and characterize a number of 11 natural plant types (Table 2). The measured values of vegetation spectral reflectance (Figure 8) indicate vegetable pigment concentration details, cellular structure, plant anomalies and humidity content, according to Wu et al (2008). The early practical utilization of spectral reflectance was oriented to determine pest infection in palm (Yones *et al.*, 2014), in strawberry (Abdel Wahab *et al.*, 2017). It is clear that that Near Infrared (NIR) and visible Blue spectral zone are the best for the discrimination between healthy and infected sugar beet plants. Fig. (9) shows the reflectance pattern of three plant; *Prunus dulcis* healthy and infected showing high similarity manner in reflectance but healthy *Prunus dulcis* reflectance is higher.

Moreover, the different infections have its specific own distinct reflection pattern. Such distinctive reflections are attributed to diversity of causative condition and symptoms related to infection type that result in somehow loss or increase in leave elements. Spectral Reflectance analysis for *Prunus dulcis*.

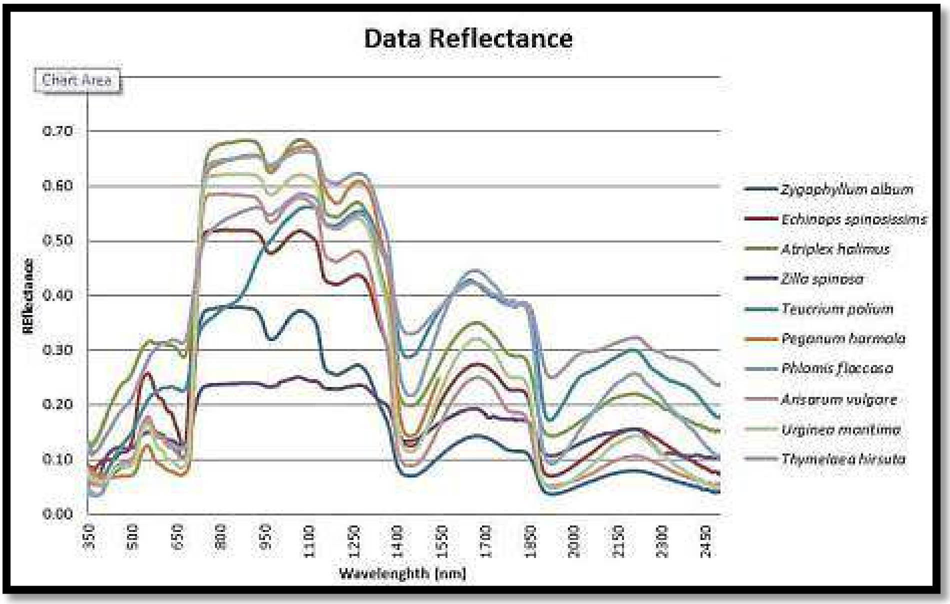

Figure 8. A number of ten wild plant species could be recognized by their spectral Signatures

Table 3. The optimum wavelength for and NDVI Value for differentiating

between Plant species.

Plant Name	Wavelength (nm)	NDVI
Arisarum vulgare	1463- 1485- 1507	0.51149
Asphodelus aestivus	1193- 1215- 1237-1259- 1281- 1303- 1325-1347- 1369-1391	0.0210
Atriplex halimus	969-991-1013-1035-1057-1079-1101-1123-1145-1167-1189-1211-1233-1255- 1277-1299-1321-1343-1365-1387-1409-1431-1453-1475-1497-1519	0.5368
Echinops spinosissims	808-830-852-874-896-918-940-962-984-1006-1028-1050-1072-1094	0.40009
Glebionis coronaria	1108- 1130- 1152- 1174- 1196- 1218- 1240-1262- 1284- 1306	0.2967
Peganum harmala	515- 537- 603- 625- 735- 757- 801- 823-911- 955- 1087	0.296792
Phlomis floccosa	1332-1354-1376	0.57858
Teucrium polium	1279- 1301- 1323- 1345- 1345- 1367- 1389-1411- 1433- 1455	0.3253
Thymelaea hirsuta	946- 968- 990- 1012- 1034- 1056- 1078-1100- 1122- 1144- 1166- 1188- 1210- 1232-1254- 1276- 1298- 1320- 1342- 1364 -1386 -1408 -1430 -1452- 1474 -1496 – 1518 -1540	0.25467
Urginea maritima	1601 -1623 -1645	0.56410
Zilla spinosa	1247 -1291 -1313 -1401	0.1286

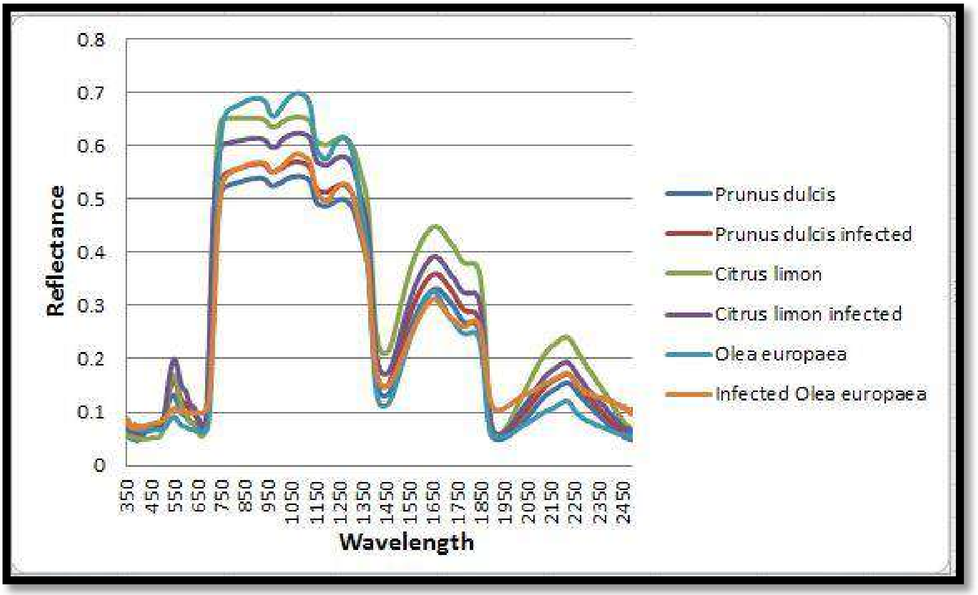

Figure 9. Spectral reflectance pattern for the three cultivated healthy and infected plants (cited from Yones, M. S. *et al. 2019*)

Note: The difference in reflectance pattern is as a result for insect devastation that results in somehow loss or increase in leave elements.

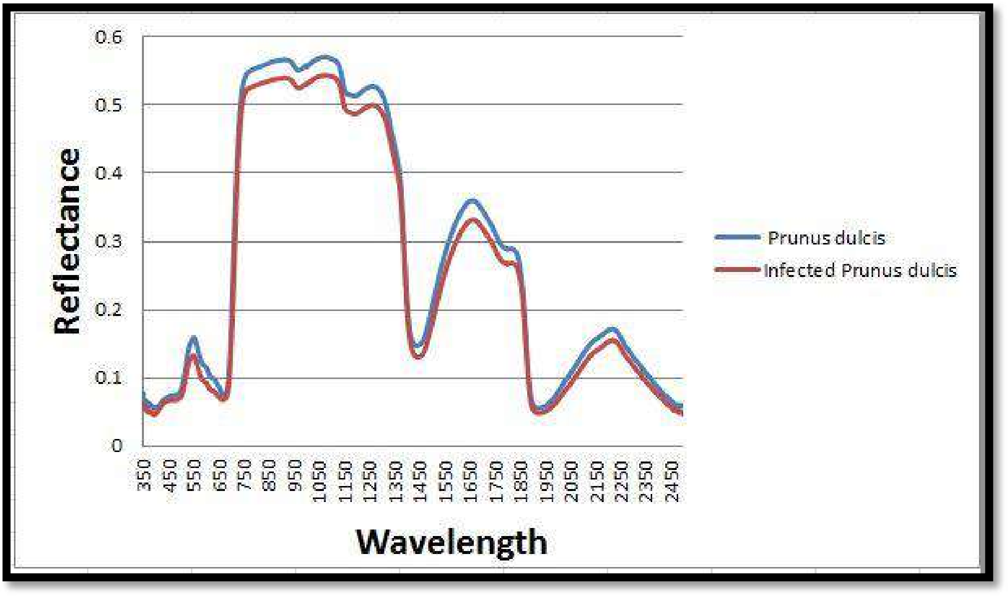

Figure 10. Spectral reflectance pattern for impact of chlorophyll on spectral reflection

6.3. Assessment and detection of pest infestation

Figure (10) indicates chlorophyll decrease at 550 nm, this result agreed with Elkins et al., 2002, as mites attacking almond trees, feeding on the leaves and remove chlorophyll. It was found that hyperspectral data assist in early identification for a diseased plant (Rumpf *et al.,* 2010).

The technical and capability progress of sensors improve the ability of obtaining hyper spectral data and specify the amount of plant pigments and its change (Blackburn, 2007).-

Assessment and detection of pest infestation was carried out in the study area from Dabaa to Foca. Twelve stands were selected to measuring plants spectrally. These stands were picked randomly at locations where there was considerable vegetation cover. Survey of pest infestation on sweet almond, citrus lemon trees and olives carried out during field observation. Spectral reflectance of all surveyed samples was laboratory measured by ASD spectroradiometer device to investigate healthy and infected plants.

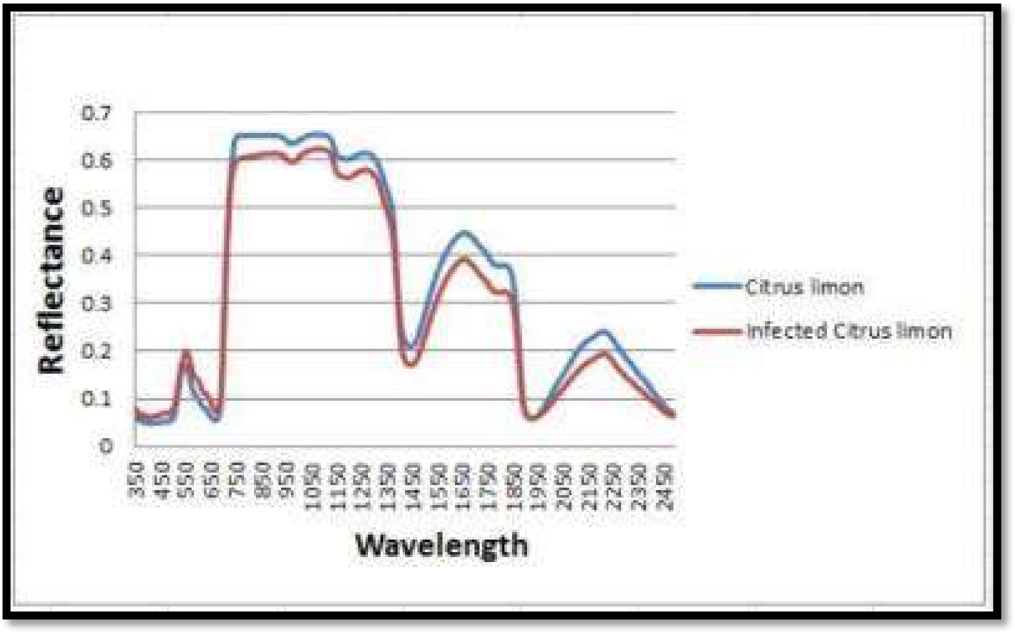

Figure 11. The Spectral Reflectance manner to Healthy and infected *Citrus lemon* by whitefly.

Spectral analysis for the *C. limon* indicates water stress (Figure 11). The stress is clearly indicated at 950, 1150 and 1450 nm, coinciding with results obtained by El-Shirbeny (2012). It is also worth full to highlight chlorophyll stress at 550 nm, which agrees with Onillon, 1990. Yones et.al. (2019) investigations on *Tukey's* HSD test for *C. limon* revealed that red and blue spectral zones easily distinguish between healthy and infected *C. limon.* The same trend is found in Citrus lemon and Olea europaea (Figure 12).

VIS-NIRS has been used for the assessment of grain, fertilizers and soil qualities in agriculture (Ben-Dor and Banin, 1995; Faraji et al . , 2004; Mohan et al., 2005) and has proven to be a simple and convenient means of simultaneously analysing several soil constituents.

Calibrated soil properties with VIS-NIRS include soil moisture determination, SOC content, electrical conductivity (EC), cation exchange capacity (CEC), soil acidity, some macro- and micro-elements (Dunn et al., 2002; Velasquez et al., 2005).

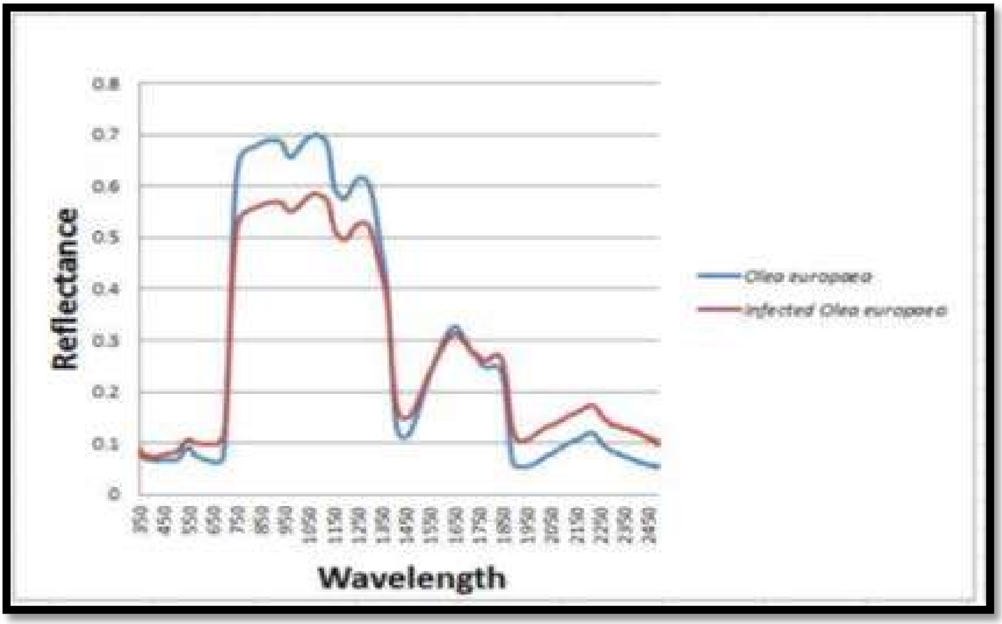

Figure 12. The Spectral reflection manner to Healthy and infected *Olea europaea* by *Prays oleae*.

Absorption in the near-infrared spectral region (780– 2500 nm) is dominated by molecules that contain strong bonds between light atoms. Specifically, these are molecules that contain C-H, N-H or O-H bonds. This makes the near infrared region particularly useful for measuring forms of carbon, nitrogen and water. VIS-NIRS is a rapid and non-destructive analytical technique that correlates diffusely reflected near-infrared radiation with the chemical and physical properties of materials (Chang and Laird, 2002). One interesting advantage of VIS-NIRS is that the size of spectrometers is rather small so that they can be field-portable (Christy, 2008). The objective of this work was to investigate the usefulness of VIS-NIRS in determining various soil chemical property (SOC content, soil acidity, content of available Mg, K, and P) and a single physical property (clay content) in topsoil (0–25 cm) from a soil sampling grid field. With that aim in mind, two calibration schemes have been elaborated. Results discrepancies between the two calibration schemes are discussed in relation to predicted sample localization and soil texture variability.

7.**Conclusion**

It is hope to use the soil and plant spectral manner as indictor linked with their characteristics and status. Few successful stories have already started with appearance of the imaging spectrometers. Jeffrey et. al. (2002) developed a database to incorporate and reference other metadata (i.e. scientific progress Data, specifications of the equipment, documents of reference, photographs and images). User could manage to locate and extract signature of interest by searching and filtering utilities. Moreover, available application tools including two- and three-dimensional Visualisation, data on signatures, and matching surfaces, in addition to exporting data are currently available, , Likewise, A good prediction was elaborated for the soil moisture content by red channel feature correlation. Different study efforts were done to link the field information with textural image analyses (AI-Abed, Lewis and Samson, 1989; Varvel *et al.* 1999; Shibusawa *et al.,* 1999).

The red channel correlation function also provided a strong predictor for the moisture content. The image processing technique is one of the difficult methods that can be used to gather field specific knowledge. Using AI-Abed, Lewis, and Samson (1989) used Cob-splitting technique for the separation of soil moisture groups used textural image analysis to estimate sludge moisture levels. While Varvel et al. (1999) attempted to use the aerial image to explain the spatial variability of cornfield organic matter and phosphorus levels. Another approach is the spectroscopic approach. Real time soil spectrophotometer has been developed (Shibusawa et al., 1999, 2CXX) and tested several times both in the laboratory and on the field (I Made Anom et al., 2001). The results showed, however, that if the original reflectance were used to predict the soil parameters without any pretreatments, the prediction accuracy was very low. When pretreatments were added to reflectance, the prediction accuracy improved but with time and soil type the reflectance wavelengths used to predict soil parameters were increasing. Many attempts have been made to improve the accuracy and repeatability of the prediction models, such as observing the surface angle effect, surface condition and surface temperature on the soil absorbance (Sato, 2001).

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