Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 2479-2484
Received: 14-07-2017
Accepted: 15-08-2017

Deepa U Pujar
University of Horticultural Sciences, Bagalkot, Karnataka, India

Udachappa U Pujar
University of Horticultural Sciences, Bagalkot, Karnataka, India

Shruthi CR
University of Horticultural Sciences, Bagalkot, Karnataka, India

Anuradha Wadagave
University of Horticultural Sciences, Bagalkot, Karnataka, India

Madhu Chulaki
University of Horticultural Sciences, Bagalkot, Karnataka, India

Correspondence
Deepa U Pujar
University of Horticultural Sciences, Bagalkot, Karnataka, India

Remote sensing in fruit crops

Deepa U Pujar, Udachappa U Pujar, Shruthi CR, Anuradha Wadagave and Madhu Chulaki

Abstract
Horticultural crops, especially fruit crops play a significant role in the food and nutritional security of the country. Hence, it is necessary to increase both production and quality. For enhancing fruit production, frequent monitoring of orchard is essential which is highly difficult because of large area coverage. Remote sensing is one of the emerging advanced technologies to gather accurate information on many parameters required for horticultural sector especially fruit crops over large area.

Keywords: Remote sensing, fruit crops, Horticultural crops, radiation

Introduction

Definition: It is process of obtaining information about land, water, or an object without any physical contact between the sensor and the subject of analysis (Remote – Not in contact with an object and Sensing – Getting information). Or it is the measurement or acquisition of information of some property of an object or phenomena by a recording device that is not in physical or intimate contact with the object or phenomena under study.

‘’Remote sensing is teaching us a new way of seeing".
Remote sensing is a multidisciplinary approach which includes different sciences such as, optics, spectroscopy, computer, satellite launching, photography and electronics. Basic knowledge of all these science is very important and it is being used in applications of remote sensing.

History: In ancient India apparently had a clear concept of remote sensing. For instance epic ‘Maha Bharata’ Sanjaya had been endowed, presumably with some equipment which enabled him to report (in real time) all the events at the distant “Kurukshetra” battle field, whether they were open or camouflaged and occurred in day or by night. History of remote sensing goes back to 18^{th} century. In recent times, Frenchman Mr. Tournachen took photographs for the first time from a balloon which floated over Paris in 1858. Earlier pigeons were used as a platform for getting information (1800) later in 1859 first time photography was taken from parachute and in 1909 from airplane. William Maxwell in 1873, he invented theory of electromagnetic spectrum (basic of remote sensing). In 1960 first TIROS meteorological satellite was launched later on landsat was launched. The term “Remote sensing” was first used in 1961 when U.S. Naval project on the study of aerial photographs was renamed as “remote sensing”. The application of remote sensing technology to agriculture and forestry was presented in couple of papers in 1968 at the occasion of U.N. conference on peaceful uses of on the space uses and the first satellite in remote sensing technology was launched in July 1972 in U.S.A. In India the remote sensing activities were initiated in 1969. After 2000s onwards work on high resolution data and development of hyperspectral sensors were going on.

Principle: Different objects based on their structural, chemical and physical properties reflect or emit different amount of energy in different wave length ranges of the electromagnetic spectrum. When a radiation falls on any object (ex. red and green apple) emits radiation in the form of electromagnetic spectrum (which carries some information about that object). These radiations are very specific to their objects and that dictates properties of object. For example, here both red and green apple emit their own pattern of radiation by which we can able to discriminate between red and green apple in terms of their color, condition and shape. Same principle is being used in remote sensing also, when radiation falls on object it emits their own pattern of radiation that radiation was detected by sensors.

Sensors: These are the device that receive electromagnetic radiation and converts it into signal that can be recorded or displayed as either numerical data or an image. There are many types of sensors are there, those are

1. Microwave radiometer
2. Gravimeter
3. Spectrometer
4. Camera
5. Solid scanner
6. Optical mechanical scanner
7. Laser water depth meter
8. Laser distance meter
9. Radar
10. Satellites also act as a sensor

Remote sensing platforms: There are 3 types of platforms based on altitude (Fig.1) on which information about objects were obtained. They are

1. Ground based: Here distance between sensors and objects will be up to 50 meters. Ex: Aerial vehicle
2. Airplane based: Here distance between sensors and objects will be up to 50 km. Ex: Parachote, Airplane and Helicopter
3. Space based: This is done at higher altitude of about100-36000 km.Ex: Satellite, Rockets and Shuttle

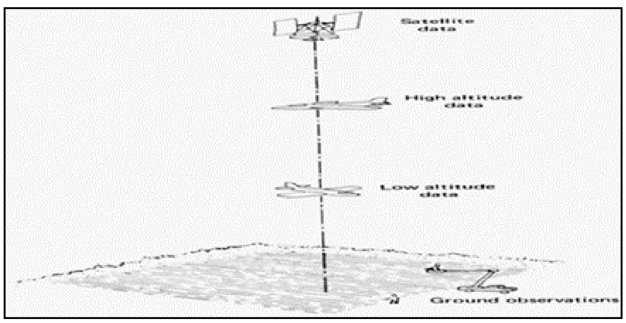

Fig 1: Remote sensing platforms at different altitude.

Basics of remote sensing

1. **Electromagnetic spectrum:** EMS is an array of electromagnetic radiation as a function of wavelength. Shortest waves are gamma rays and longest waves radio waves. Longer the wavelength stronger will be the transmittance (Fig. 2).

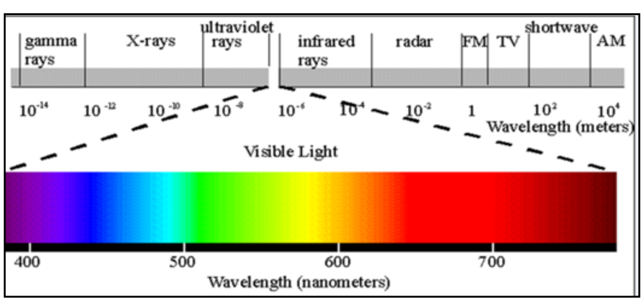

Fig 2: Electromagnetic spectrum

Understanding of different electromagnetic waves is very important to know about object and its properties based on reflected radiation. In different condition *viz.*, high temperature, stress condition, drought stress etc different radiations with varied wavelength will emit which carries information about objects.

A. **Wavelength**: It is a distance between consecutive crest and trough.

B. **Frequency**: Number of wave cycles completed per unit time per unit distance (Fig. 3).

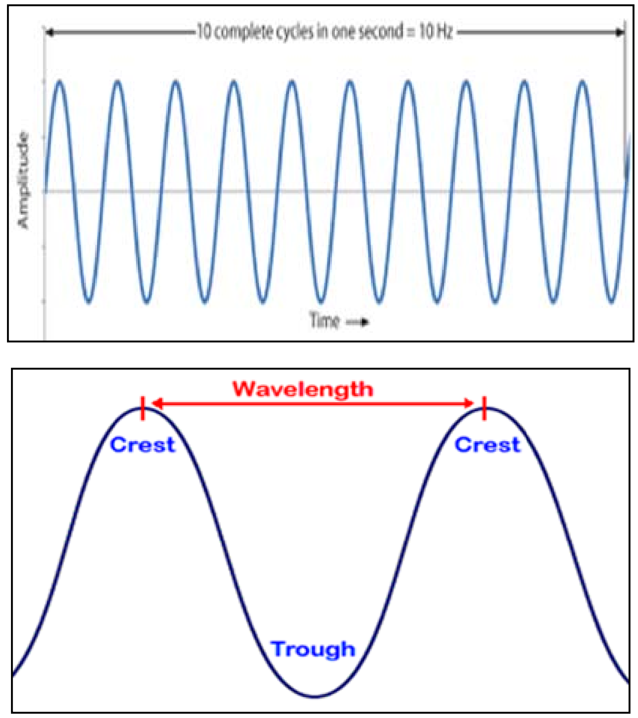

Fig 3: Frequency and wavelength of radiations

Radition taget (object) interaction: When radiation falls on object, there will be three interactions takes place between radiation and object. Those are

1. Transmittance- Incident radiation will transmit through object or target. This radiation is of no use.
2. Absorption- When radiation falls on target it is absorbed into the target. It is also of no use.
3. Reflection- When radiation falls on target it is reflected from target and revert back its direction. This radiation is perceived by sensor and informaton will be analysed. Only this radiation is used in remote sensing technique.

Radiation atmosphere interaction: There are three interaction are there. It happens only when satellite used as platform where radiation has to be interact with atmospheric layer.

1. Scattering- Radiations were scattered by atmospheric constituents such as ozone, CO_2 and water vapor.
2. Absorption- Radiations are absorbed into atmospheric constituents.
3. Transmittance- Radiations are transmitted through atmospheric layer.

Amoong these interactions scattered and absorbed radiations were not used in remote sensing. But transmitted radiation will be carrying some information about object that can be received by sensor for getting information. So, we should select radiations in such a way that it should be strongly transmissible through atmospheric layer without absorption and scattering.

Atmospheric Windows: These are the radiations (areas of the spectrum) which are not severly influenced by atmospheric absorption and which are useful to remote sensors, are called as atmospheric windows (Table 1).

Table 1: Major Atmospheric Windows-

Radiations	Wavelength
UV and VIS	0.30-0.75 µm
Near Infrared	0.77-0.91 µm 1.55-1.75 µm 2.05-2.40 µm
Thermal Infrared	8.00-9.20 µm 10.2-12.4 µm
Microwave(Radar)	7.5-11.5mm 20.00+ mm

These are some radiations are atmospheric windows which are not either bsorbed or scattered by atmosphere. These can be used in remote sensing technology.

Spectral Signature: Any Remotely sensed parameter, which directly or indirectly characterizes the nature and or condition of the object under observation, as defined as spectral signature. Hence, it is the ratio of reflected energy to incident energy as a function.

$\rho(\lambda)$ = **[ER(λ) / EI(λ)] x 100ρ**
(λ) = Spectral reflectance (reflectivity) at a particular wavelength.
ER (λ) = Energy of wavelength reflected from object
EI (λ) = Energy of wavelength incident upon the object

Resolution: The smallest measurable/observable difference. It measures clearance of image or information. There are four type of resolutions.

1. Spectral resolution: Part of EMS measured.Single image aws taken with different spectral bands for getting higher accuracy.
2. Radiometric resolution: Smallest difference in energy that can be measured. Single image is taken with single wavelength at different intensities (8-14 bit).
3. Sptial resolution: Smallest unit area measured.Ability of senor to resolve two adjecent things as separate or distinct.
4. Temporal resolution: Time between two successive image aqusition over same area. EX.Landsat- temporal resolution 18 days (takes observation once in 18 days).

IRS satellite – 5 days (takes observation once in 5 days)

Components of RS

1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem (Fig.4).

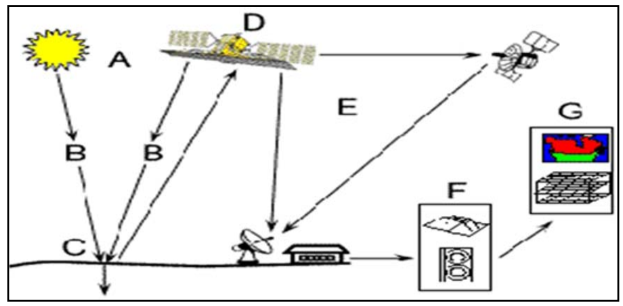

Fig 4: Components of remote sensing

Types of Remote Sensing

1. Based on Source of energy: This is based on source of energy used in remote sensing technique. There are 2 types.

A. **Passive remote sensing**: In this type solar energy is used as a source of energy. This operates only in day condition whenever sunlight is available.

B. **Active remote sensing**: As name indicates this requires artificial source of energy. It can be operate in both day and night condition (Fig.5).

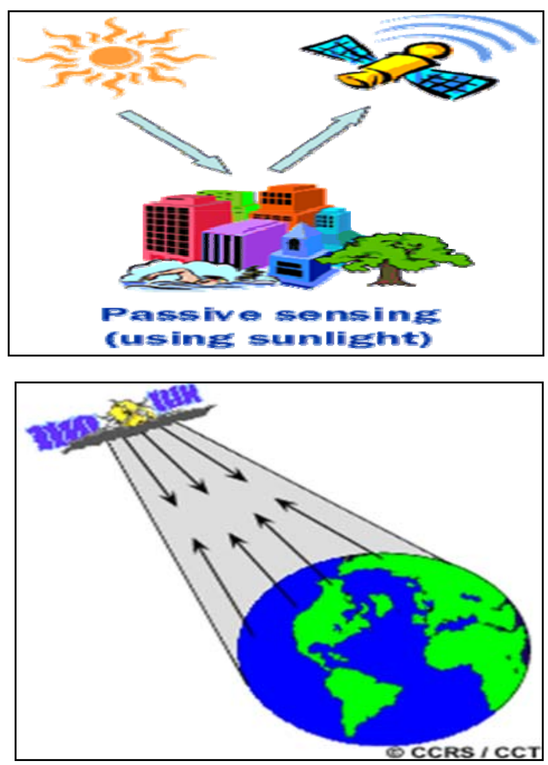

Fig 5: Passive and Active remote sensing

2. Based on Range of Electromagnetic Spectrum: This is based on type of electromagnetic radiation used in remote sensing. There are 3 types.

A. **Optical Remote Sensing**: This measure at a wavelength of 300 nm to 3000 nm. Which includes Visible, near infrared, middle infrared and short wave infrared portion
B. **Thermal Remote Sensing**: This measure at a wavelength of 3000 to 14000 nm. It records the energy emitted from the earth.
C. **Microwave Remote Sensing**: This measure at an wavelength of 1 mm to 1 m. Active sensors are used in this type of remote sensing, hence this can operates in all weather and environmental conditions.

Some known satellites which operates at different wavelength

1. NOAA-AVHRR (1100 m)
2. GOES (700 m)
3. MODIS (250, 500, 1000 m)
4. Landsat TM (1972) and ETM (30 – 60 m)
5. SPOT (1986)(10 – 20 m)
6. IKONOS (1999) (4, 1 m)
7. Quickbird (2001) (0.6 m)
8. CARTOSAT (2005)
9. IRS- series (1988)
10. AVHRR-Advanced Very High Resolution Radiometer
11. FORMOSAT (2004)
12. ALOS (2006)

Major image processing software's: There is a need to analyze information after receiving from reflected radiation by sensors. Many software's were used to analyze this data. Some of software's were listed her below.

1. ENVI/IDL: http://www.rsinc.com/
2. ERDAS Imagine: http://www.gis.leica-geosystems.com/Products/Imagine/
3. PCI Geomatics: http://www.pci.on.ca/
4. ER Mapper: http://www.ermapper.com/
5. INTEGRAPH: http://imgs.intergraph.com/gimage/
6. IDRIS
7. Ecognition: http://www.definiens-imaging.com/ecognition/pro/40.htm
8. ILWIS
9. ArcGIS

Applications: This remote sensing technique has a many applications especially in orchard pants (grown in large scale). This technique differentiates between healthy and stressed plants by radiations reflected by them. This helps to detect water stress, involved in assessment of pre harvest fruit quality, early detection of pest and disease, yield estimation, recommendation of fertilizer dose and also cultivable land area estimation.

Advantages: As frequent monitoring is difficult especially in case of orchard plant (large area cultivation), but this techniques provides regular synoptic view over large area. It is possible to get accurate results of fertilizer dose recommendation, land mapping, irrigation intervals etc. Most important one is, it saves energy and time. One person can handle thousand hectare lands.

Disadvantages: Since satellites are very expensive to build and launch, it is expensive technology. Only large farmers can afford this technology and it can be employed at community level. It needs expert system and software's to extract data. Analysis should be done with care to get proper results.

Remote sensing organisations: These are some remote sensing organizations at national and international level

1. **ISPRS**- International Society for Photogrammetry and Remote Sensing
2. **IGARSS**- International Geoscience Remote Sensing symposium
3. **NASA-** National Aeronautic and Space Administration (USA)
4. **ESA**- European Space Agency (Europe)
5. **NASDA**- National Space Development Agency (Japan)
6. **CNES**- Centre National d'stedesSpatiales (France)
7. **DARA-** German Space Agency (Germany)
8. **CSA**- Canadian Space Agency (Canada)
9. **ISRO**- Indian Space Research Organisation (Banglore, Karnataka)
10. **NRSA-** National Remote Sensing Agency on India (Balanagar, Hyderabad)

Vegetation indices: These were used as remote sensing indicators. Reflectance values at different wavelength were incorporated in equation for getting particular parameter. Different vegetation indices are indicators for different parameters such as NDVI for vegetation cover, SIPI for stress etc. (Table 2).

Table 2: Vegetation indices: **(**Remote sensing indicator)

Parameter	Expansion	Equation
1. NDVI	Normalised Difference Vegetation Indices	R_{800}-R_{670} / R_{800}+R_{670}
2.TCARI	Transformed Chlorophyll Absorption in Reflection Index	3*[(R_{700}-R_{670})-O.2*(R_{700}-R_{550})*R_{700}/R_{670})]
3.OSAVI	Optimised Soil Adjusted Vegetation Index	(1+0.16)*(R_{800}-R_{670})/R_{800}+R_{670}+0.16)
4.SR	Simple Ratio	R_{800}/R_{670}
5.PRI	Photochemical Reflectance Index	R_{570}-R_{531}/R_{570}+R_{531}
6.SIPI	Structure Insensitive Pigment Index	R_{800}-R_{445}/R_{800}-R_{680}
7.CTVI	Corrected Transformed Vegetation Index	NDVI+0.5/abs*(NDVI+0.5). [√abs(NDVI+0.5)]
8. RVSI	Red Edge Vegetation Stress Index	(R_{714}+R_{752}/2)-R_{733}
9. MSR	Modified Red Edge Simple Ratio	(R_{800}/R_{670})-1 /(√R_{800}/R_{670})+1
10.WBI	Water Band Index	R_{900}/R_{970}
11.WMI	Water Moisture Index	R_{1600}/R_{820}
12.PI	Photosynthesis Index	R_{531}-R_{570}/R_{531}+R_{570}
13.RN	Nitrogen Index	R_{550}-R_{600}/R_{800}-R_{900}
15.CI	Chlorophyll based Difference Index	R_{850}-R_{710}/R_{850}-R_{680}

Applications

1. Estimation of cultivable land area and mapping of orchards

Remote sensing systems have the capability of providing regular, synoptic, multi-spectral and multi-temporal coverage of an area. Mustaq and Asima (2014) [3] have estimated Apple orchard using remote sensing and agro-metrology land based observation in Pulwama district of Kashmir valley. They have taken different parameters *viz*., terrain parameters like elevation slope and aspect facilitates better characterization of apple orchards. These parameters can be further utilized for apple orchard area expansion. Landsat and AWIFS digital data were used to monitor and estimate acreage under apple orchards. The Survey of India (SOl) topographical maps at 1:50,000 scales and image-to image registration were used to geo- reference the images and crop statistics from State department of horticulture were used as ancillary data. With this they found that majority of apple orchards (89.82%) are concentrated between elevation range 1500-2000 mts. Apple area above (2000m) is about 10% while under lower elevations <1500m) is about 0%. The terrain parameters indicated that the dense orchards lie in the elevation range 1500-2000 meters. Thus these sites can be used as reference sites to standardize site suitability and management plan of apple orchards. Since the density matched well with the age of plantation, sites belonging to dense category may be ones that need planning for rejuvenation.

2. Recommended dose of fertilizer application

Site-specific grove management by variable rate delivery of inputs such as fertilizers on a tree size basis could improve horticultural profitability and environmental protection. Zaman *et al*., (2005) [6] have studied variable rate nitrogen application in Florida citrus based on ultrasonically-sensed tree size. Tree canopy sizes were measured real-time in a typical 17-ha Valencia grove with an automated ultrasonic sensor system equipped with Differential Global Positioning System (DGPS). Prescription maps for variable application of nitrogen fertilizer were generated from ultrasonically scanned tree sizes on a single tree basis using ArcView GIS and Midtech Fieldware. Leaf samples from trees with different canopy sizes, which had been fertilized at a conventional uniform rate of 270 kg N/ha/y, were analyzed for nitrogen concentration. Analysis of 2980 tree spaces in the grove showed a skewed size distribution, with 62% in the 0- to 100-m3/tree volume classes and a median volume of 79 m^3 /tree. The tree volumes ranged from 0 to 240 m^3 /tree. Regression analysis showed that trees with excess leaf nitrogen (>3%) had canopies less than 100 m3. These trees receiving excess nitrogen are likely to have lower fruit yields and quality, and wasted fertilizer nitrates may leach beyond the root zone to groundwater. In order to rectify the excess fertilization of smaller trees, a granular fertilizer spreader with hydraulically powered split–chain outputs controlled with a MidTech Legacy 6000 controller was used for variable rate application of nitrogen in one–half of the grove. A 38% to 40% saving in granular fertilizer cost was achieved for this grove when variable N rates were implemented on a per-tree basis ranging from 135 to 270 kg N/ha/y.

3. Detection of water stress

Remote sensing technology can also helps in identification of water stress by change in leaf colour. Many techniques such as high spatial resolution multispectral and thermal airborne imagery were used to monitor crown temperature and the Photochemical Reflectance Index (PRI) in peach orchards. Different irrigation regimes included sustained and regulated deficit irrigation strategies, were employed to induce stress. Results revealed that there was a difference in reflectance pattern between well irrigated and stressed plants (Saurez *et al*., 2010) [5].

4. Assessment of quality

Quality is one of the important parameter which is ultimate aim of any producer. In grape wine quality was assessed by vigour of vine which is directly correlated (Johnson *et al*., 2001) [2]. Remotely sensed vegetation index imagery was used to establish sub–block management zones in a 3–ha commercial vineyard of Chardonnay wine–grapes. Subsequent ground–based measurements revealed a clear differentiation between low– and high–vigor zones with respect to biomass (primarily shoot vigor), vine water status, and most importantly, fruit and wine character. Harvesting by vigor zones allowed for the extraction of unique wine lots from a block that was historically treated as a single management unit. This aspect alone has value in that the winemaker was provided with greater flexibility in the final blending process.

5. Early detection of pest infestation

Remote sensing techniques can decrease pest monitoring costs in orchards. Ludeling *et al*. (2009) evaluated the feasibility of detecting spider mite damage in orchards by measuring visible and near infrared reflectance of 1153 leaves and 392 canopies in 11 peach orchards in California. Pairs of significant wavelengths, identified by Partial Least Squares regression, were combined into normalized difference indices. These indices were evaluated for correlation with mite damage. Eight spectral regions for leaves and two regions for canopies (at blue and red wavelengths) were significantly correlated with mite damage. Index values were linearly correlated with mite damage (R2 = 0.47), allowing identification of mite hotspots in orchards. However, better standardization of aerial imagery and accounting for perturbing environmental factors will be necessary for making this technique applicable for early mite detection.

6. Detection of disease incidence

Remote sensing is emerging as an important component of precision agriculture for its ability to identify and define crop health. Changes in spectral reflectance can indicate physiological stress in trees that result from the changes in photosynthetic pigments such as chlorophyll, carotenoids and other factors. With improvements in spatial, spectral and temporal resolution of remote sensing, multispectral imagery remains advantageous due to its real-time or near real-time imagery for visual assessment. With this imagery technique it is possible to detect infected trees and healthy trees. Sindhuja *et al.,* (2013) [4] reported that there was a difference in average reflectance. Values of the healthy trees in the visible region were lower than those in the near infrared region, while the opposite was the case for HLB-infected trees. This could helps in taking up of immediate control measures, so that spread of disease could be minimised.

Conclusion

Remote sensing is a valuable tool for frequent monitoring orchards at high spatial resolution which allow site specific economically favourable management strategies. Helps in reducing monitoring costs, enhances resource use efficiency, lowering total production cost and Increases profit.

References

1. Eike L, Adam H, Minghua Z, Walter JB, Cecil D. Remote sensing of spider mite damage in California peach orchards. Int. J. App. Earth Observation and Geoinformation. 2009; 11(3):244-255.
2. Johnson LF, Bosch DF, Wiiliums DC, Lobitz BM. Remote sensing of vineyard management zones: Implications for wine quality.Applied Eng. In Agri. 2001; 17(4):557-560.
3. Mushtaq G, Asima N. Estimation of apple orchard using remote sensing and agro-meteorology land based observation in Pulwama district of Kashmir valley. Int. J. Remote sensing and Geo. Sci. 2014; 3(6):2319-3484.
4. Sindhuja S, Joe M, Sherrie B, Reza E. Huanglongbing (Citrus Greening) detection using visible, near infrared and thermal imaging techniques. Sensors. 2013; 13(6):2117-2130.
5. Suarez L, Zarco TPJ, Gonzalez V, Berni JA, Sagardoy R, Morales B, Fereres E. Detecting water stress effects on fruit quality in orchards with time-series PRI airborne imagery. Remote Sensing Env. 2010; 114(4):286-298.
6. Zaman QU, Schumann AW, Miller WM. Variable rate nitrogen application in florida citrus based on ultrasonically-sensed tree size. Am. Soc. Agril. Engineers. 2005; 21(3):331-335.