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Spectral Signatures of Plant

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In particular, disease, insect pests, water stress, nutritional stress and drought are the factors that lower agricultural productivity are due to biotic and abiotic stress which were caused by climate change. Spectral monitoring mitigates these stressors through advanced prediction. Climate change cause biotic and abiotic stress in plant especially disease, insect pest, water stress, nutrient stress, drought are the factors that reduce crop yield. Spectral monitoring mitigates these stresses by advanced prediction. Due to increased surface and ground water pollution brought on by over-fertilization of agricultural lands and the need to account for spatial variability in a field, spectral monitoring in crop production is becoming more and more popular. Additionally, recent trends in global agriculture prices have created a new scenario for agricultural policies globally. A major contributor to price volatility in agricultural markets and social instability in many regions of the world is climate unpredictability. A crucial factor in detecting supply irregularities is crop monitoring and yield predictions. It enables quick, well-informed market adjustment and policy action, averting food emergencies and market disruptions thereby decreasing market speculation and boosting food security generally.

Various remote sensors are used to record the spectral data emitted or reflected electro magnetic radiation by the crop. Most promising approach is to use proximal and remote sensing technologies like ground based active optical sensors that detect the disease, insect pest, water stress and nutrient stress. Among them ground based crop reflectance measurement sensors are SPAD chlorophyll meter, CropCircle, CropSpec. GreenSeeker and Yara N-Sensor are the most popular sensors used in agriculture domain to collect the spectral characters of plant.

Spectral signature

Spectral signature is the variation of reflectance or emittance of a material with respect to wavelengths (*i.e.*, reflectance/emittance as a function of wavelength).

Plants reflect electromagnetic energy in a unique way. The term "spectral signature" refers to this distinctive quality of the plant. In the electromagnetic spectrum, vegetation reflects very little in the blue and red, a little more in the green, and a lot in the near infrared band (NIR). The factors which have an impact on a crop's spectral signature are growth stage of the crop, chlorophyll pigmentation and other pigments, crop nutrient content, crop water content, leaf area and internal structure of the leaf and infestation by pests and disease.

Important wavelengths used for spectral monitoring are

Blue band: 455-492 nm
Green band: 492-577 nm
NIR band: 750-950 nm
Short-Wave IR band: 1550-1750 nm

These are the few spectral bands which are mostly used in remote sensing.

Spectral reflectance characteristics for green plants

Crop plant absorb the majority of the visible light (400-700 nm), with the maximum absorption occurring at blue (400-500 nm) and red (600-700 nm). Green light is reflected more strongly in the visible spectrum than other colors. Due to the interior structure of the leaves and the effect of water content on reflectance at near and mid-IR, healthy crop reflects more in the IR region than the majority of other objects (900-1300 nm). Reflection of IR decreases owing to vigour loss, pest and disease infestations, and stress; spectral reflectance in the green band is only 10% to 15%; spectral reflectance in the IR band is 40% to 60%.

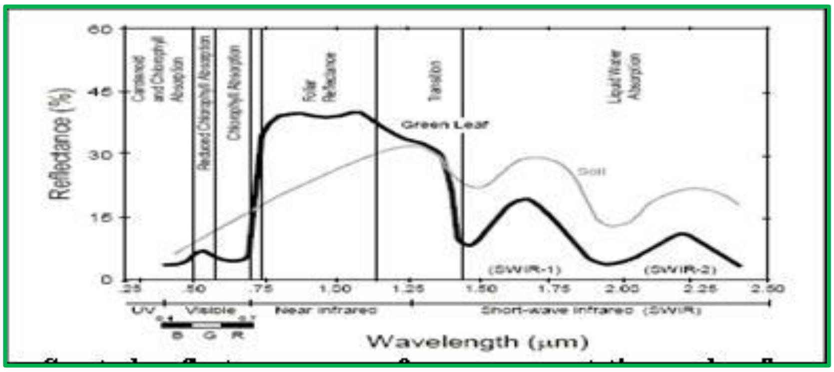

Fig. 1: Spectral reflectance curves for green vegetation and soil (Tucker and Sellers, 1986)

The Figure 1 indicates that due to the presence of chlorophyll and beta-carotene pigments in plants, the most absorption was noticed in the visible range, particularly in the red and blue region, and the highest reflectance in the green as well as near infrared regions. Figure 2 indicates that healthy vegetation showed highest reflectance in NIR region as compared to stressed or severally stressed. Whereas, healthy vegetation reflected less in visible spectrum as compared to stressed vegetation.

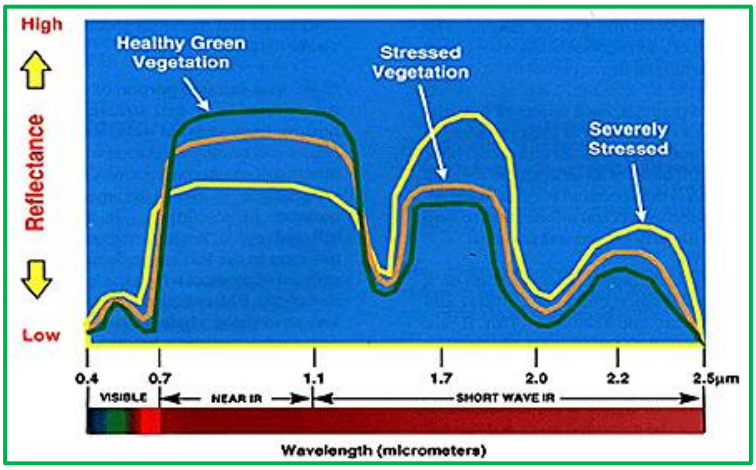

Fig. 2: Spectral reflectance curves for healthy green vegetation and stressed vegetation

What is the need of spectral reflectance in agriculture?

Spectral reflectance data provide real-time and non-destructive estimates of plants biotic and abiotic stress, and account for spatial and temporal variability of crops and soil. Spectral monitoring in agriculture is required to assess the chlorophyll concentration in plant, growth and yield assessment, nutrient recommendation to crops, to determine crop water stress and soil moisture and to assess the damage caused by insect disease and weeds.

Various indices used for crop studies few of them are enlisted below:

1. Ratio Vegetation Indices (RVI) = NIR / Red
2. Normalized Difference Vegetation Index (NDVI) = NIR-Red / NIR+Red
3. Transformed Vegetation Index (TVI) = √NDVI+0.5
4. Perpendicular Vegetation Index (PVI) = √ (Red Soil-Red Veg.)^2+ (NIR soil –NIR Veg.)^2
5. Differential vegetation Index (DVI) =NIR-Red