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Applying Remote Sensing Techniques to Identify Early Crop Infestation: A Review

Meaghan Metzler

Abstract:

In this review remote sensing techniques will be looked at to determine if vegetation damage due to infestation is reflected by changes in spectral signature; early detection of infection and disease is beneficial in that it could effectively prevent wide spread destruction and harm to the crop. Within this review, the experimenter's objective, experimental design, methods for data collection, and results determined will be discussed for rice infested with sheath blight and blast, and for grapefruit infested with greasy spot. General conclusions will also be discussed.

Introduction:

Remote sensing is the process whereby information can be obtained from a source without actually coming in contact with it. This process of obtaining data has definite advantages when applied to agriculture processes. Crop stress associated with some form of infestation, be it bacteria, fungus, virus, or insect pests, does cause changes to the vegetation. The distinct changes in morphology are predominantly monitored through human visual inspection; however, this can be unreliable due to the fact that everyone's discernment can be different, so there is little quality control. If remote sensing techniques are implemented to discern the spectral differences associated with disease, this could reduce the addition of human error to the disease monitoring process.

The main advantages attributed with incorporating remote sensing techniques into agricultural farming are reduction in cost for pesticide application and less damage to the environment. Because infestations are not normally evenly distributed within a crop, it would be more efficient to only apply pesticide directly to the site of infestation, rather than to large areas. This would greatly reduce the cost – cost of buying the pesticide, cost of running the machinery to apply it, and cost of human labor required to manually apply it – for the farmer. Also, reduction in wide spread pesticide use would help to prevent the onset of resistance in the pest species, and decrease the amount of harmful pesticides entering the environment.

Remote Sensing Techniques Applied to Rice Infected by Sheath Blight:

The experimenter's objective here was to examine the possibility of incorporating broadband airborne remote sensing to rice sheath blight disease detection and diagnosis. The rice field that was used for the study was located in Hazen City, Arkansas; it was approximately 762m in length and 476m in width. The field used for this study was naturally infected by sheath blight *Rhizoctonia solani*, a fungus that spreads from the site of infection at the waterline to the heading, causing a decrease in rice grain production.

Using ADAR (air borne data acquisition and registration) four images were acquired. The system used had four bands: 450nm - 540nm (blue region), 530nm - 600nm (green region), 610 - 680nm (red region), and 780 - 1000nm (near infrared region), with a spatial resolution of 1m. The digital number used ranged from 0 – 255. The field sampling was divided into 11 strips and 50 sampling sites.

Three indices were also used for evaluation of disease severity:

- SHBDI = % infected tillers
- SHBDH = height (cm) of sheath blight symptoms
- TH = height (cm) of plant canopy above soil

An all-inclusive ground disease index was determined from the three indices:

- Ground disease index (DI) = SHBDI *SHBDH / TH

The results generated show that the change of ground disease index can be seen as the proportional change with the image pixel DN values; however the trend is weak in all bands[3]. Only band 4 had a higher correlation between the disease index and the direct band DN values. It was concluded that higher spatial resolution and spectral resolution is required to diagnose crop disease efficiently and with improved accuracy.

Remote Sensing Techniques Applied to Rice Infected by Blast:

The experimenter's objective here was to observe the changes in the spectral signature of infected rice plants using spectrodradiometer and remote sensing techniques[2]. The rice field that was used for the study was located in a nursery field at Nattaf Research Station in Giza, Egypt; it was 70 faddens (nearly 73 acres) in size. The field used for this study was infected with blast *Pyricularia oryzae*, a fungus that causes rot to spread from infected nodes, causing decreased rice grain production.

Spectroradiometer readings were taken in the infected rice field during the growing season (July through October); the readings measured the reflected radiance flux in four wavelengths 0.5 - 0.6µm (green region), 0.6 - 0.7µm (red region), 0.7 - 0.8µm (near infrared region), and 0.8 - 1.1µm (near to middle infrared region). The reflectance measurements were referenced with a white paper panel. Ratio Vegetation Index (RVI) and Normalized Difference Vegetation Index (NDVI) were also calculated in addition to the spectral measurements recorded.

– RVI = Infrared(B7) / Red(B5)
– NDVI = (Infrared(B7) – Red (B5) / (Infrared(B7) + Red(B5))

The results produced demonstrate that the first changes occur in the near-infrared region (0.7 – 1.1µm); at the primary stages of the infection by blast there is a decrease in both green (0.5 – 0.6 µm) and the near infrared (0.8 – 1.0 µm) regions[2]. The experimenters concluded that the initial changes seen in the visible spectral region rather than in the infrared regions were due to the sensitivity of chlorophyll to physiological disturbance[2]. In addition to these conclusions they recommend that more analysis should be done using infrared and thermal wavelengths.

Remote Sensing Techniques Applied to Rio Red Grapefruit Infected by Greasy Spot:

The experimenter's objective here was to determine if airborne hyperspectral imaging provided more accurate citrus pest stress identification and monitoring than airborne multispectral imaging. The grapefruit field that was used for the study was located at the Texas A&M University-Kingsville Citrus Center in Weslaco, Texas; the field size covered 9.2 acres. The field used for this study was naturally infected by greasy spot *Rhizoctonia solani*, a fungus causing the common citrus foliar disease which reduces tree vigor and fruit production.

The multispectral image had three different filters: 845 – 857nm (near infrared region), 625nm – 635nm (red region), and 555nm – 565nm (yellow-green region). The spatial resolution was 0.7m. Unsupervised classification was performed and three different classes were determined: bare soil, shadow, and vigorous trees[1].

The Hyperspectral image was a pushbroom system, with 128 spectral bands ranging from 457.2nm – 921.7nm, with a spectral resolution of 3.63nm, and a spatial resolution of 1.3m. Unsupervised classification yielded six different classes: grass, unhealthy leaves along with the previous four classes were determined[1].

The conclusions made by the experimenters is that hyperspectral imagery provides more accurate information about vegetation health because it gives plenty of spectral information and can provide more accurate classifications[1].

General Conclusions:

Each of the experiments discussed above similarly did not use satellite based remote sensing techniques; reason being satellite technology does not have the needed high spatial resolution required to view individual vegetation species. The experiments sensing the effects of sheath blight and greasy spot on rice and grapefruits respectively, both used airborne platforms to obtain their images for analysis. The experiment determining the effects of blast on rice used a spectroradiometer. The main contribution that all three experiments provided was confirmation that remote sensing techniques can be used to verify vegetation damage occurring through infestation can be determined via the spectral signature of the plant species.

Because satellite data acquisition is still not useful for smaller field sizes and individual plant species, airborne data and spectroradiometer acquisition is the most practical; however, these two methods do require more thought into the actual data recovery – such as where the samples will be taken from (if using the spectroradiometer), and how often. Because human input is necessary in all aspects of non-satellite data acquisition, there is also the risk of human error. It is with this that the major disadvantage occurs. However, remote sensing techniques are highly valuable because they can be used to determine vegetation conditions more accurately than past techniques.

References

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