Is there spectral variation in the polarized reflectance of leaves?

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Introduction: Our prior research

There is no spectral information in the polarized portion of the bidirectional reflectance factor BRF(55°,0°;55°,180°) of healthy green leaves in the 400-800nm wavelength region.

Results

Bidirectional Reflectance Factor (BRF) spectra are typical of green leaves – green peak at 550nm, red minimum around 650-680nm, red edge between 700-720nm, near infrared plateau between 760 and 1100nm, large water absorption bands at 1,450 and 1,940nm.

Results

- Polarized BRF spectra (below) of green leaves appear reasonably flat – and, unlike the BRF spectra (Results upper-left), display no peak in the green wavelength region, minimum in the red, a red edge, maximum in the near infrared, nor evidence of water absorption bands at 1450 and 1940nm.
- 5 of 7 polarized BRF spectra generally increase between 500 and 2500nm wavelength.
- Polarized BRFs of ficus and spathiphyllum cross over: ficus > spathiphyllum for 1050nm < λ < 1900nm and ficus < spathiphyllum for λ < 1050nm and λ > 1900nm.
- Derivatives (i.e. slopes) of polarized BRF spectra vary with wavelength from negative to near zero to positive.

This research

Is there hyperspectral information in the polarized portion of the bidirectional reflectance factor BRF(55°,0°;55°,180°) of healthy green leaves in the 500-2500nm wavelength region?

Approach

- Measure detached leaves
  - cannabis
  - coffee
  - philodendron
  - spathiphyllum
- Leaf petioles in vials of water
- Incidence = Reflection = 55°
- Approximately Brewsters angle
- ASD FieldSpec Pro Spectroradiometer
- 1° fore optic
- Wire grid polarizer 500-2400nm
- Calibration with Spectraon™ surface

Conclusions

- No hyperspectral variation in the polarized BRF of leaves of five plant species measured 500-2500nm.
- No evidence chlorophyll or water absorbed polarized light, because measured spectra are flat.
- Results support hypothesis that light from leaf is polarized during first surface, quasi specular reflection. Polarized light never entered leaf to interact with pigments and water.
- We use “quasi specular,” because electron micrographs reveal that on all leaves an amorphous wax surface supports particles and structures – leaf surface is not optically smooth.
- General increase in the polarized BRF from 500 to 2500nm wavelength is due to leaf surfaces better approximating optically smooth surface at 2500nm than at 500nm.
- More data needed to assess if polarized BRF cross-overs and slope changes are typical of polarized spectra or represent measurement noise.
- Degree of linear polarization (DOLP) (polarized BRF divided by BRF) varies dramatically with wavelength only because BRF varies dramatically with wavelength.