RESEARCH ON THE POLARIZED CHARACTERISTIC OF LEAF

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1 INTRODUCTION

Plant leaves are the main organs for photosynthesis, which can affect the growing process, and the optical characteristics of leaves are the most primary factors effecting the distribution of directional reflectance of canopy. Therefore it is the foundation of reflectance from canopy to research the scattering character of a single leaf qualitatively and quantitatively[1].

The researches show that leaves are neither pure diffuse nor specular reflectors[2-4]. Instead, they have both diffuse and specular characteristics. The diffuse, Lambertian character of leaf reflectance emanates primarily from the interior of the leaf through multiple scattering; and the specular and non-Lambertian character of leaf reflectance arises at the surface of the leaf. In addition, polarized reflectance of leaf surface, arising from leaf specular reflectance component, is also important and significant for polarized remote sensing[5,6].

2 MEASUREMENT AND ANALYSIS OF POLARIZED BRDF FROM LEAF

In this paper, the polarized bidirectional reflectance factor (BRF) from several leaf surfaces were measured by a goniometer developed by Changchun Institute of optics, fine mechanics and physics, Chinese academy of sciences[5], including tender corn leaf, mature corn leaf, and lilac leaf. The illumination zenith angle was set to 20°, 30°, 40° and 50° respectively. Three states, including unpolarized, 0° polarized and 90° polarized BRF were measured.

Based on the measurement data, we can find that with the increasing of incident zenith angles from 20° to 50°, the specular peak values enhanced remarkably, which showed the non-Lambertian properties of leaf. When the incident angle was 50°, BRF in specular direction is close to 1.0. Specially, as the big incident zenith angles, the locations of the specular peaks moved to the bigger view zenith angle.

The 0° and 90° polarized BRFs were similar with the unpolarized data, except that the 0° polarized data were bigger than the 90° polarized data accordingly. Additionally, the specular peak values of corn mature leaf were bigger than those of corn tender leaf and lilac leaf because its surface is much smoother.

3 THE DEGREE OF POLARIZATION

The degree of polarization was calculated based on those measured polarized BRF data correspondingly.

Some common characteristics of them can be obtained. Firstly, whole of the degrees of polarization increased with the increasing of incident zenith angle. At the same time, if view angle is near nadir, the degrees of polarization just changed a little with the increasing of incident angle. Secondly, fixing the incident zenith angle, the degrees of polarization also raised with the increasing of view zenith angle basically. In other words, the degree of polarization was concerned with the incident and view directions tightly.

4 CONCLUSION

From our study, some conclusion can be obtained: (1) the polarized BRF were similar with the unpolarized BRF, except the variation of specular peak values; (2) non-Lambert properties of reflectance of leaves surfaces were prominent, even for the roughness leaf surface, for example, tender corn leaf with many villi; (3) the degrees of polarization increased with the increasing of the incident and view zenith angle, and the greater of the incident and view zenith angle, the greater of the degrees of polarization.

Additionally, the degree of polarization was also related with the refractive index and roughness of reflecting surface and diffusion component. But it is complex and difficult to understand how those factors influence the degree of polarization of leaf surface. It required a physical polarized BRDF model of leaf to describe and analyze the polarized characteristics of reflectance of leaf surface. The next work will put emphases on building the physical polarized BRDF model and on connecting the parameters of leaf surface and physiological parameters with the degree of polarization.

The leaves chosen here cannot represent all cased of leaves. Therefore the rules obtained here were restricted by only these samples measured. Later, other leaves sample will also be included to measure and analyze quantitatively.

5 REFERENCES

[1] Zhang, H. and Zhu, Q., The reflection characteristics of healthy green leaves[J], Journal of Remote Sensing, 1(Supp.1):36-47, 1997

[2] Grant, L., Diffuse and specular characteristics of leaf reflectance. Remote Sensing of Environment, 22:309-322, 1987

[3] Brakke, T.W., Smith, J.A., and Harnden, J.M., Bidirectional scattering of light from tree leaves[J], Remote Sensing of Environment, 29:185-183, 1989

[4] Walter-Shea, E.A., Norman, J.M. and Blad, B.L., Leaf bidirectional reflectance and transmittance in corn and soybean, Remote Sensing of Environment, 29:161-174, 1989

[5] Zhao Y., Huang F., Jin L., and so on, Study on polarizing reflectance characteristics of plant simple leaf, Journal of Remote Sensing, 4(2):131-135, 2000.

[6] Grant, L., Daughtry, C.S.T., and Vanderbilt, V.C., Measurements of specularly reflected radiation from leaves, Purdue Univ., LARS Tech. Rep. 081583, 1983