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6 Optical properties of plant surfaces

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6.1 Introduction

Plant organs are composed of many tissue types containing specialised cells differing in chemical composition and structure. This complexity results in complicated and variable interactions between radiation and plant matter. Among plant organs, the optical behaviour of leaves is probably the most studied because of its importance to the photosynthetic process (Terashima, 1989; Björn, 1992; Vogelmann, 1993; Smith *et al.*, 1997; Evans, 1999; Carter and Knapp, 2001; Ustin *et al.*, 2001; Vogelmann and Evans, 2002; Evans and Vogelmann, 2003), and for the interpretation of remote sensing data (Buschmann and Nagel, 1993; Zwiggelaar, 1998; Carter and Knapp, 2001; Ustin *et al.*, 2004).

This chapter reviews the optical characteristics of plant surfaces. As all three authors of this review are interested in various aspects of photosynthesis in higher plants, we primarily focus on surface optics of green leaves but also briefly discuss the surface optics of fruits and flower petals. In this review, we define 'plant surface' as any peripheral layer with the potential to influence radiation conditions inside the photosynthetic mesophyll of leaves; that is, the cuticle, epidermis and, in some cases, sub-epidermal layers. We consider natural ultraviolet (UV) radiation, which comprises of UV-B (280–315 nm) and UV-A spectral range (315–400 nm), because UV radiation can not only drive photosynthesis (McLeod and Kanwisher, 1962; Mantha *et al.*, 2001) but is also able to damage various components of the photosynthetic machinery (Day and Neale, 2002; Hollósy, 2002; Jordan, 2002; Kakani *et al.*, 2003). Naturally, we also discuss surface optics in the visible wavelength range (400–700 nm) which is the main energy source for photosynthesis: this spectral range can also damage components of the photosynthetic machinery if light energy is absorbed in excess of photosynthetic capacity (Osmond *et al.*, 1997; Huner *et al.*, 1998; Niyogi, 2000; Krieger-Liszkay, 2005). In this review, we restrict the use of the term 'light' to visible radiation only.

We briefly describe current methods for analysing surface optics and then discuss, in detail, not only optical surface properties arising from electronic absorption of radiation by pigments but also those resulting from non-absorptive interaction of radiation with matter: plant surface optics, of course, integrates both of these optical aspects.

Rather than provide complete coverage of the literature we have opted to concentrate on several especially interesting facets of surface optics in plants, and we apologise to those workers whose important works have not been cited. Consistent