4 Water Uptake by Organs Other Than Roots

P.W. RUNDEL

CONTENTS

4.1 Introduction ................................................................. 111
4.2 Foliar Uptake of Water in Vascular Plants ......................... 114
  4.2.1 Foliar Uptake of Water in Arid Zone Flowering Plants ...... 114
  4.2.2 Foliar Uptake of Water by Bromeliads ...................... 116
  4.2.3 Foliar Uptake of Water by Orchids .......................... 118
  4.2.4 Foliar Uptake of Water by Poikilohydric Angiosperms .... 119
  4.2.5 Foliar Uptake of Water by Poikilohydric Ferns and Fern Allies 120
4.3 Water Uptake by Bryophytes ............................................ 121
  4.3.1 Background ...................................................... 121
  4.3.2 External Conduction of Water ................................. 121
  4.3.3 Internal Conduction of Water ................................. 122
4.4 Water Uptake by Lichens ............................................... 124
4.5 Conclusions .................................................................. 127
References ........................................................................... 128

4.1 Introduction

The extensive early literature on foliar uptake of moisture, spanning nearly three centuries, has been reviewed by STONE (1957a, 1970) and GESSNER (1956a). Early field studies by a number of workers demonstrated water uptake by leaves or stems of intact plants (LLOYD 1905; WETZEL 1924; KRAUSE 1935). These and other laboratory experiments (see STONE 1957a, 1970) led to a unanimity of opinion on the ability of leaves to absorb water, but a strong divergence of views on the ecological and physiological significance of this uptake. Remarkably, however, the flow of papers on the subject over the past 50 years has done little to resolve the questions of significance, and foliar water uptake remains as controversial a subject as ever.

There is no question of what the theoretical basis of foliar uptake of water should be. The physical requirements are a gradient of decreasing water potential from the atmosphere to a leaf and through a plant to the soil. Such conditions can be expected to occur in arid and semi-arid habitats where atmospheric vapor pressure deficits are low at night and soil water potentials may be −2 to −3 MPa or lower. In theory, neither saturated atmospheric conditions nor dew point temperatures on leaf surfaces are required for water uptake and
transfer to occur. Only a source of water and a favorable water potential gradient are necessary.

Given this background, it is important to set up a series of ecophysiological criteria by which reported examples of foliar uptake of water should be judged. Such uptake must occur in sufficient amounts to increase plant water potentials significantly through direct means rather than indirectly through reduction of transpiration. Thus the following conditions should be met for a critical acceptance of a study:

a) a gradient of decreasing water potential from atmosphere to plant (or even soil) must be present;

b) morphological or anatomical structures must be present to speed water uptake;

c) significant amounts of water must be absorbed and redistributed within the plant; and

d) plant water potentials must be significantly increased by direct effects.

A great many studies have demonstrated that individual criterion are met in specific circumstances. Transport of water from air to root systems and even into soil has been demonstrated in a number of studies (Breazeale et al. 1950, 1959a, b; Breazeale and McGeorge 1953a, b; Haines 1952, 1953; Slatyer 1956). Some conflicting results to these studies have been reported, however (Höhn 1954). Slatyer (1960) reviewed this subject in some detail and discussed the potential significance of leaf and root resistance to water transport, as well as the importance of the magnitude of water potential gradients.

Observations from early agricultural studies that natural or artificial dew could increase the growth of certain plants (see Stone 1970) have long been cited as evidence for foliar uptake of water. More recently similar observations have been reported for a number of species of conifers. Drought-stressed seedlings of Pinus and other conifers in California have increased longevity when artificial dew is applied to their foliage (Stone et al. 1950; Stone 1957b, 1964; Stone and Fowells 1955; Stone et al. 1956). Pinus mugo (Eizenzopf 1952) and P. sylvestris (Härte and Eizenzopf 1953) in Europe show similar responses. Waisel (1958) found increased water potential of P. halepensis following overnight exposure to dew, and later demonstrated direct water uptake into needles using tritiated water (Vaadia and Waisel 1963). Dew absorption through the leaves of drought-stressed Ceratonia siliqua (a broad-leaved evergreen) overnight increases their water content by 10% (Waisel 1958). Johnston (1964) reported that plantations of Pinus radiata were able to maintain subcritical needle water contents under drought conditions when frequent light rains and fogs were present. An anatomical basis for foliar uptake of water by P. radiata has been suggested (Leyton and Armitage 1968).

While these studies would collectively appear to provide strong evidence for accepting the foliar uptake of water as an important physiological mechanism, the individual studies still fail to meet all of the criteria for critical acceptance which were described above. The tritiated water studies (Vaadia and Waisel 1963) lack a demonstration of the magnitude of absorption and the degree of redistribution of this water through the plant. Other studies where