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Dew formation and water vapor adsorption in semi-arid environments—A review

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Abstract

The impact of 'non-rainfall' water on soil is important in arid zones. In that environment, the amount of dew can exceed that of rainfall, or even be the sole source of liquid water for plants. However, since plants cover only a small fraction of the desert surface, such assessments apply only to a small proportion of the area. In the absence of fog, dew formation and direct water vapor adsorption are two mechanisms by which water can be added to the soil. The latter has been much less extensively studied, even though in many instances the environmental conditions favor its occurrence over dew formation. The different physical mechanisms underlying these two phenomena are described in this review, followed by a description of the most commonly used methods to quantify and monitor them. Which of these two phenomena will occur is determined by soil-surface temperature. Dew forms on the soil surface only if the surface temperature drops below the dew-point temperature. Otherwise, water vapor adsorption is the only possible mechanism for water uptake by the soil. It has become clear that there are areas in which, during the dry season, the dominant process is vapor adsorption, and dew formation is a rare occurrence. Since it is during the dry season that the importance of dew has always been considered to be most significant, these findings put in doubt the role of dew as a water source in desert areas.
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Keywords: Dew formation; Dew duration; Water vapor adsorption

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1. Introduction

As far back as biblical times, dew was considered a precious and life-supporting phenomenon. It was mentioned as a source of great fertility (Genesis 27:28; Deuteronomy 33:13; Zechariah 8:12) and its withdrawal was regarded as a curse from God (2 Samuel 1:21; 1 Kings 17:1). It was deemed a symbol of wealth (2 Samuel 17:12; Psalms 110:3), an emblem of brotherly love and harmony (Psalms 133:3), and of rich spiritual blessings (Hosea 14:5). Later, a popular story dating back to the 16th century told of the hundreds of liters of dew water that were formed yearly by condensation of water vapor on a sealed sarcophagus located in the yard of the abbey of Arles-sur-Tech (France) (Beysens et al., 2001). In more modern times, the lack of potable water in certain arid areas has been at the heart of a renewed interest in dew formation and its possible use to supply water needs. Nikolayev et al. (1996) reviewed the idea of dew collection in light of the basic physics of water vapor condensation. Awanou and Hazoume (1997) proposed the use of different types of radiators for hot and dry climates based on the psychrometric diagram. The possibility of storing dew was investigated in the Canary Islands (Hollermann and Zapp, 1991), as was the prospect of condensed atmospheric moisture for use in small-scale irrigation (Alnaser and Barakat, 2000).

In agriculture, dew may play different roles (Wallin, 1967). On the one hand, it may be beneficial to crops by decreasing the vapor-pressure deficit in the vicinity of the dew drops and thus allowing stomatal opening and photosynthesis (Slatyer, 1967). Moreover, despite the small amount of free liquid water involved in the process of dew formation, it can play an important role in the recovery of water content in plants after extreme water loss (Went, 1955). On the other hand, the presence of dew on the leaves of agricultural crops can have a negative effect, as it may lead to the spread of various plant diseases. An important factor in plant disease control and protection is duration of leaf surface wetness, as the spores of many pathogens need a film of water on the leaf tissue in order to germinate and infect the host (Pedro and Gillespie, 1982a; Morin et al., 1993). In particular, the development of bacteria and fungi has been found to be highly influenced by the presence of dew (Auld et al., 1988; Zuberer and Kenerley, 1993; Zhang and Watson, 1997). Thus, most models of crop foliar diseases include factors related to both pathogen biology and the environmental regulation of the presence of dew (Wilson et al., 1999).

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