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Evaluation of wheat and maize evapotranspiration determination by direct use of the Penman–Monteith equation in a semi-arid region

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The Penman–Monteith (PM) equation was introduced as one of the most reliable equations to determine crop ET_c, without using crop coefficient or ET_o values. In this study, the PM equation was evaluated using lysimeters in a semi-arid region for wheat and maize. Different equations for aerodynamic resistance (r_a) and canopy resistance (r_c) were tested in the PM equation and they were ranked using statistical analysis. It was shown that the combined method of r_a and r_c in FAO-56 does not lead to a good prediction of ET_c for wheat and maize in comparison with the lysimeter-measured data. The results indicated that a modified equation for r_c was the most accurate method for both wheat and maize. Using this equation, the suggested model of FAO-56 and another investigation for r_a led to the best results for wheat and maize, respectively. Furthermore, it was shown that the previously modified equation for r_c was newly modified as a function of vapor pressure deficit (VPD) and the results were as accurate as before. Therefore, an equation as a function of VPD can be used when solar radiation (R_n) is not available easily.

Keywords: Penman–Monteith; crop evapotranspiration (ET_c); aerodynamic resistance (r_a); canopy resistance (r_c); wheat; maize; lysimeter

Introduction

Methods of determining crop evapotranspiration under standard conditions (ET_c) can be divided into two general categories: (1) ET_c measurement by lysimeter and (2) ET_c estimation methods. In the first category, ET_c values are usually measured directly using instruments such as a weighing lysimeter (Rana and Katerji 2000). In the second category, ET_c is estimated by means of the relationships between different parameters. This is achieved by use of empirical equations that are based on reference evapotranspiration (ET_o) and crop coefficients (K_c), i.e. $ET_c = K_c \times ET_o$. The Penman–Monteith (PM) equation, as a standard method for ET_o estimation, had been known as an appropriate method in comparison with other equations in different regions of the world (Allen et al. 1989, 1994a,b, 1998; Jensen et al.1990; Smith et al. 1991; Razzaghi and Sepaskhah 2009).

Another method is an analytical formula similar to the PM equation that can estimate ET_c directly without estimation of ET_o and K_c. Calculation of crop evapotranspiration using the direct method seems to be more accurate than indirect

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