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Estimating crop coefficients for apple orchards with varying canopy cover using measured data from twelve orchards in the Western Cape Province, South Africa

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ABSTRACT:

The FAO-56 crop coefficient (K_c) approach is widely used for making irrigation decisions. Allen and Pereira (2009) extended this approach by developing a method for estimating K_c using a density coefficient (K_d), which is estimated from the fraction of ground covered by vegetation and plant height. In this study we evaluated this method using detailed measurements of transpiration (T), evapotranspiration (ET), soil attributes, weather, and tree physiological variables in 12 apple (*Malus domestica* Borkh.) orchards in the Western Cape Province of South Africa. Mid-summer canopy cover of the orchards was less than 20 % in young non-bearing and exceeded 60 % in mature full-bearing orchards. Data were collected over three growing seasons (October 2014 to May 2017) in orchards planted to the Golden Delicious/Reinders®, Cripps Pink, Cripps Red, and Rosy Glow apple cultivars. The original Allen and Pereira (A&P) method significantly overestimated the basal crop coefficients (K_{cb}) by on average 47 % in mature and 103 % in young orchards, respectively. However, improved K_{cb} estimates were obtained by adjusting the ratio of the resistances (i.e. r_l /100) in the A&P method, where r_l is the mean leaf resistance and 100 s/m is the typical resistance for annual crops. We defined a resistance parameter "α" for apple orchards which is equivalent to the bulk canopy resistance of a well-watered tree. Replacing r_l /100 with r_l /α, and using the measured mean r_l and other biophysical measurements to solve the A&P equation for α gave a value ~ 37 s/m. The improved K_{cb} values were used to derive the orchard K_c taking into account the contribution of cover crops whose transpiration was measured using miniature stem heat balance sap flow gauges. The seasonal total transpiration (T) estimated as $T = K_{cb} \times ET_o$, where ET_o is the reference ET closely matched

the measured values with a RMSE (root of the mean square error) of ~ ±16 mm. Therefore, using the mean canopy resistance which is representative of apple trees in the A&P method has the potential to accurately predict both the crop coefficients and water use of apple orchards from planting until full bearing age.