A Simple Irrigation Scheduling Approach for Pecan Irrigation in the Lower Rio Grande Valley

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ABSTRACT

Pecan is a major crop in the lower Rio Grande Valley (LRGV), New Mexico. Currently, about 12,000 ha of pecan orchards at various stages of growth are consuming about 45 percent of irrigation water in the area. Pecan evapotranspiration (ET) varies with age, canopy cover, soil type, crop density and method of water management. The intense competition for the limited water supply in the area has created a serious need for better water management through improved irrigation scheduling. Pecan annual ET varies from as low as 500 mm to as high as 1400 mm. The diversity of the crop coefficient and ET makes the task of irrigation scheduling in this particular crop very complicated.

Using remote sensing technology and field ET measurement, a simple relationship was developed to relate crop coefficient and ET to canopy cover. This relationship is then used in combination with climate data to calculate daily and weekly water requirement for each orchard.

The methodology provides a simple tool that a typical farmer can use to schedule irrigation for pecan orchards.

INTRODUCTION

Pecan is a major crop in Lower Rio Grande Valley (LRGV) currently comprising about 46% of the irrigated acreage. Pecan production in LRGV has steadily increased in the past 40 years reaching to about 30,000 acres in 2008. Pecan is a major cash crop in NM with average annual income of 40 million dollars. Pecan is also a major water user. A mature pecan orchard can consume about 4.3 ft of water per year. The high water use and increasing acreage of pecan combined with periodic and severe drought in NM has created an urgent need for better understanding of pecan consumptive use and better management of water in the area.

There are various methods to estimate crop water use, but because of the diversity of pecan age, spacing, density and management practices, real time estimation of crop consumptive use is complex and beyond the reach of individual farmers. This paper describes a simple approach to estimate average daily and monthly crop ET.

METHODOLOGY

Using remote sensing technology, a simple relationship was developed to relate crop coefficient and ET to canopy cover. This relationship is then used in combination with climate data to calculate daily and weekly water requirement for each orchard.

The methodology provides a simple tool that a typical farmer can use to schedule irrigation of Pecan orchards. The remote sensing uses Landsat images combined with surface energy balance technique to calculate daily water use on the ground. The regional ET estimation model (REEM, Samani et al, 2007, 2009) calculates ET as a residual of surface energy balance. The methodology is similar to one presented by Bastiaanssen et al (1988) with some modification as described by Samani et al (2008) where the latent heat flux (LE) was determined as a residual of the surface energy equation:

$$ET = R_n - G - H \quad (1)$$

Where, ET is the latent heat flux (evapotranspiration), R_n is the net radiation flux at the surface, G is the soil heat flux, and H is the sensible heat flux to the air.

After calculating daily ET, monthly and annual ET values, pecan fractional cover in various orchards was estimated using a series of infrared-DOQQs images which were taken from aerial flights. Fractional cover was estimated using supervised classification of the masked and subset color infrared DOQQs. Supervised classification is a common method used to group pixels similar in reflectance based on training classes. The training phase consists of assigning sets of pixels to a particular class based on previous knowledge of the image or verification on the ground (Bastiaanssen, 1998).

Figure 1 shows a relationship between annual ET and fractional cover (f_c) for 279 pecan orchards. The information in figure 1 was used to develop a relationship between relative crop coefficient and fractional cover (figure 2). The relative crop coefficient was defined as the ratio of average annual crop coefficient of an orchard (k_c) to that of a fully mature reference orchard with canopy cover of about 80 percent in which daily ET was measured using an eddy covariance flux tower.(Reveles, 2005).

Using figure 2, and the K_c of the reference orchard, the daily, weekly or monthly kc values for individual orchards can be estimated as:

$$K_c = (\frac{K_c}{K_{c-ref}})K_{c-ref} \quad (2)$$

In which $K_{c\text{-}ref}$ represent the crop coefficient of the reference orchard. The monthly k_c values for the reference orchard are shown in Table 1.

Table 1, Measured monthly K_c for the reference Pecan orchard (K_{c-ref}) using flux tower

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kc	0.38	0.36	0.39	0.59	0.87	1.02	1.04	1.24	1.26	0.84	0.39	0.38

Once the K_c values are estimated, the daily crop ET can be estimated using the relationship between crop ET and reference evapotranspiration estimated from climate data as:

$$ET = K_c \cdot ET_0 \quad (3)$$

in which ET is daily, week or monthly ET and ET_0 is reference evapotranspiration calculated from Hargreaves-Samani equation (1985) or Penman-Monteith (ASCE-EWRI 2005).

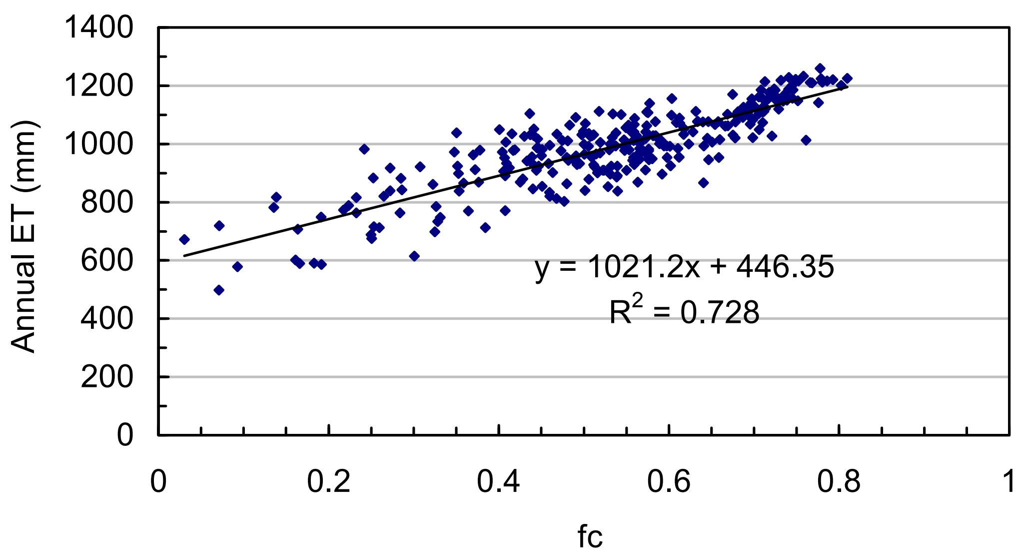


Fig. 1. Relationship between Annual Pecan ET and fractional cover (f_c) for various orchards.

Figure 3, 4 and 5 compare the estimated monthly pecan K_c with remotely sensed K_c values of the same orchards for three fractional cover of 40%, 60% and 73% respectively.

FIELD COMPARISON

The methodology described above was used to estimate monthly ET for a young pecan orchard with average fractional cover of 52%. An eddy covariance flux tower installed in the same orchard was used to measure daily ET. Figure 6 compares measured and estimated monthly ET for the orchard. The maximum monthly ET difference is about 9.5%.

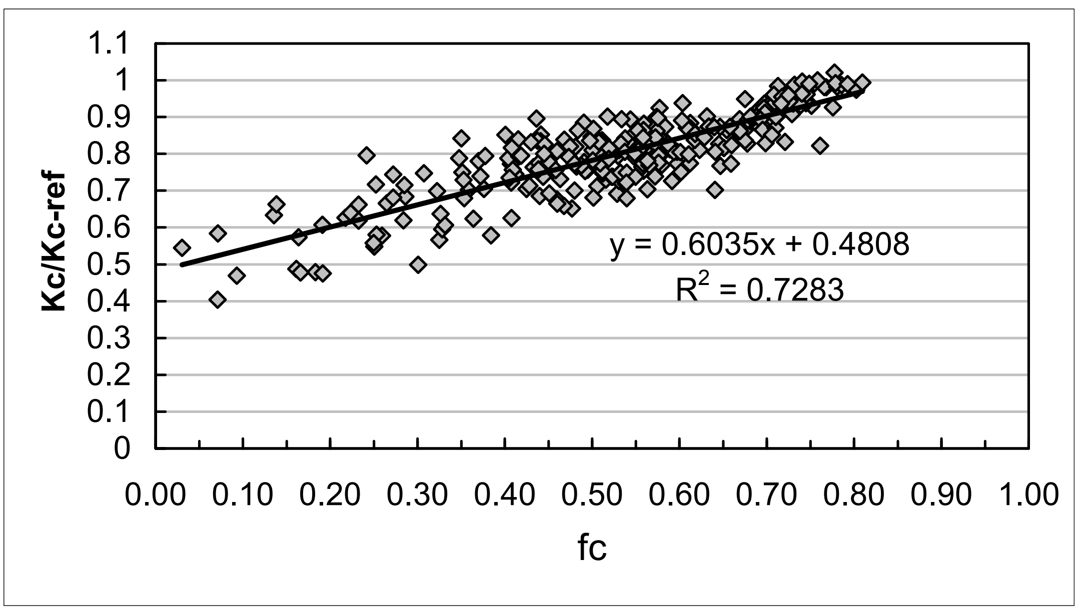


Fig. 2. Relationship between relative crop coefficient and fractional cover (fc).

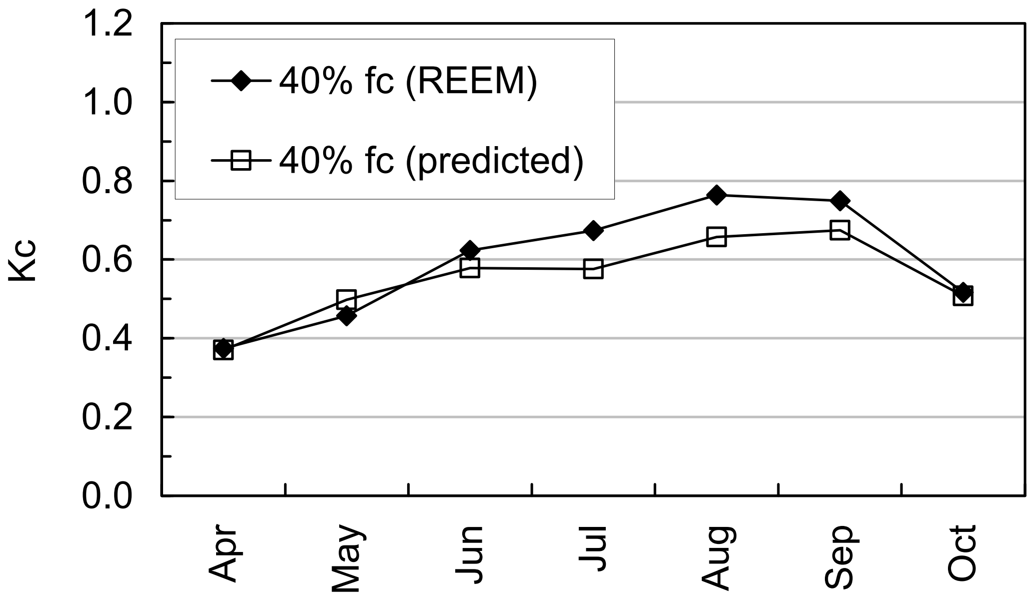


Fig. 3. Comparison of estimated K_c with remotely sensed K_c for 40% fractional cover

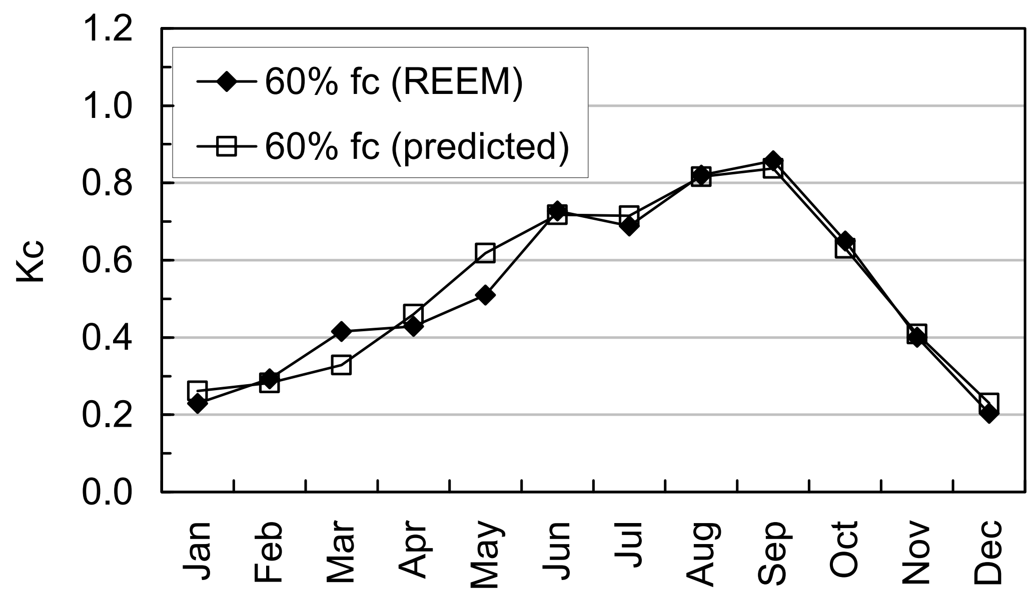


Fig. 4. Comparison of estimated K_c with remotely sensed K_c for 60% fractional cover

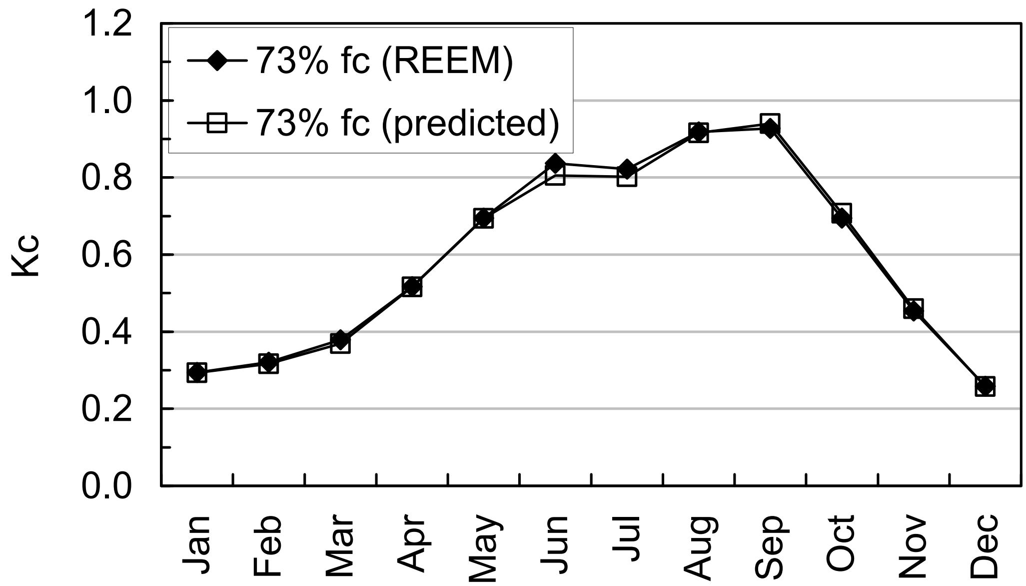
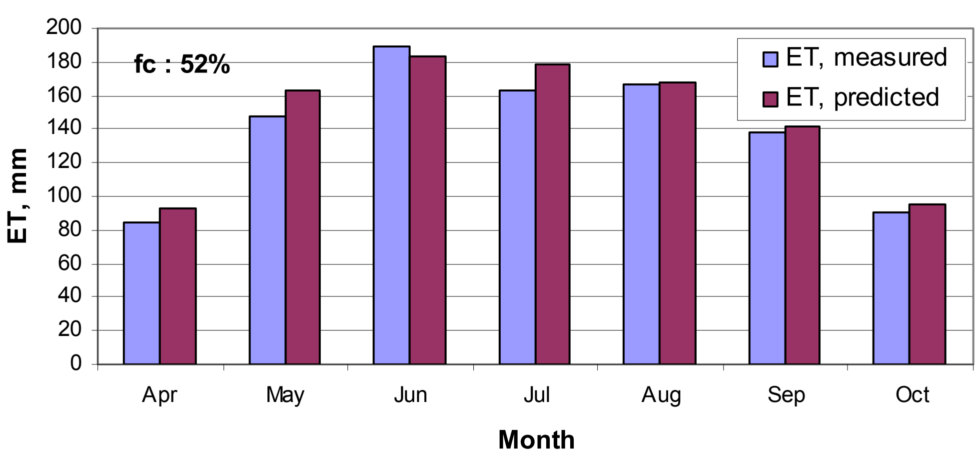


Fig. 5. Comparison of estimated K_c with remotely sensed K_c for 730% fractional cover



CONCLUSION

A simple procedure is presented where crop fractional cover/canopy cover can be used to estimate average daily ET of pecan. The comparison between measured ET and predicted ET showed that average monthly ET can be estimated with high accuracy. The procedure provides a simple approach to calculate pecan ET. The information can then be combined with soil physical properties to develop irrigation schedules for each orchard.

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