Estimations of crop factor and evapotranspiration for rain-fed paddy rice field, cassava plantation and teak plantation in Thailand

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1. Introduction

Numerous empirical and theoretical models have been presented in recent decades for predicting evapotranspiration from crop fields. However, application of the models accompanies difficulties in finding the proper values of crop parameters included in these models. The main aim of the present investigation is to find out an empirical equation consisting of easily available climatic parameters for estimating crop factors (K_c) as well as evapotranspiration (ET) in three popular vegetations in North East Thailand and Chao-Phraya River basin.

2. Material and methods

The measurements were carried out at three measurement sites in Thailand, a rain-fed paddy rice field (17° 03' N, 99° 42' E, 50 MSL) in Sukhothai province, a cassava plantation (14° 47' N, 102° 38' E, 311MSL) near Nakhonratchasima and a teak plantation (18° 40' N, 99° 47' E, 241 MSL) in Lampang province (Fig.1). Evapotranspiration measurements were carried out using the Bowen ratio energy balance method (BREB) during 1999-2004 (Fig.2). Penman-Monteith equation recommended by the FAO (Allen, et al., 1998) was used to estimate daily reference crop evapotranspiration (ET_0) as follows:

$$ET_0 = \frac{0.408\,\Delta(R_n - G) + \gamma(900/T + 273))u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Crop coefficients (K_c) for the paddy field, cassava and teak plantations were calculated using the relation $K_c = AET/ET_0$. The correlations between K_c and climatic factors and soil moisture content were then examined.

Fig.1 Location of the measurement sites.

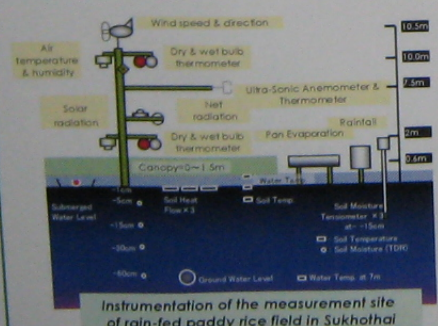

Fig.2 Instrumentation in measurement site of paddy rice field.

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3. Results and discussion

Based on daily mean data, our results showed that the primary factors whicht affect K_c ratio are solar radiation (R_s), air temperature (T_a), wind speed (WS), vapor pressure deficit (VPD) and soil water content (SWC) (Fig.3)..

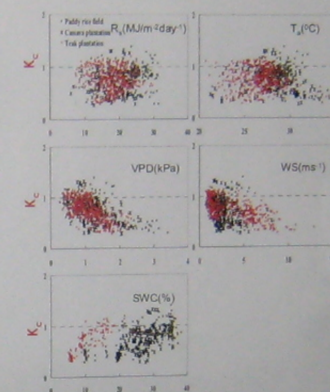

Fig.3 Correlation between Kc factor and meteorological parameters.

Multiple correlation coefficients (r) between the K_c and five above-mentioned factors in the paddy field, cassava and teak plantation were about 0.75, 0.73 and 0.93, respectively(Fig.4).

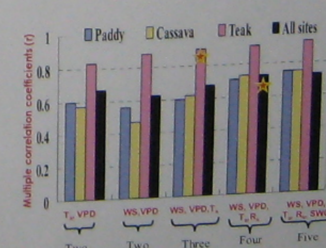

Fig.4 Multiple correlation between Kc factor and meteorological parameters.

Since the factors excluding SWC produced almost same multiple correlation coefficients in three sites, and soil moisture is sometimes unavailable data, the authors proposed the following equation using the whole data in the three sites by four climatic factors:

$$K_c = (0.202) + (0.014{*}R_s) + (0.026{*}T_a) - (0.009{*}WS) - (0.355{*}VPD)$$ **(multiple correlation coefficient: r = 0.73)**

Estimated K_c then multiplied to ET_0 to calculate estimated ET. Fig.5 shows the correlation between estimated and measured ET in three measurement sites. Root mean square error (RMSE) was approximately 0.8 mm/daytime on a 1-day scale. Since average value of ET was about 3.8 mm/daytime, RMSE at one day scale correspond to 21% of average ET while RMSE at a 10-days scale was 13%. Then, we conclude that averaging over more than 10 days is suitable to estimate ET by the proposed equation.

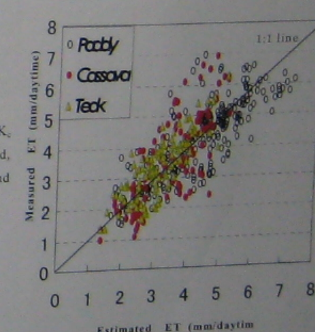

Fig.5 Relationship between estimated ET and measured ET in three measurement sites (1999-2004)

4. Conclusion

We conclude that the proposed equation is available to use for estimating of evapotranspiration of various types of vegetation in Thailand for more than 10 days average.