ESTIMATE CROP EVAPOTRANSPIRATION OF SPRING WHEAT IN THE MIDDLE REACHES OF HEIHE RIVER BASIN, NORTHWESTERN CHINA

Yao Wang[1], Chuanyan Zhao[1],Zhonglin Xu[2],Huanhua Peng[2]

(1. Key Laboratory of Arid and Grassland Agroecology with the Ministry of Education,
Lanzhou University, Lanzhou 730000, China
2. Key Laboratory of Western China's Environmental Systems with the Ministry of Education,
Lanzhou University, Lanzhou 730000, China)

1. INTRODUCTION

Actual crop evapotranspiration (ETc) is not only the important component of water balance, but also an important requirement for proper constitution of irrigation strategy. The great challenge for the constitution of irrigation strategy is increase of food production to ensure food security for the growing population, particularly in the arid regions of northwest China due to scarcity of water resource[1]. In this study, the middle reaches of Heihe river is selected as the study area. Our objective is to simulate the diurnal changes of evapotranspiration of spring wheat during growing season using daily meteorological data and crop phonological data.

2. MATERIALS AND METHODS

2.1. Study area

The middle reaches of Heihe River (96°42′- 102°00 ′E and 37°41-′42°42′N) is located in the northwest China, covering 17,000km² in total. The elevations range from 1131 to 2891 m. The climate is characterized by arid because the area is situated in the inner part of Asia–Europe continent. The mean annual precipitation varies from about 250 mm in the southern area with the highest elevation to less than 100 mm in the northern plain area with the lowest elevation. The mean annual air temperature is 8℃ at the lower (northern) part of the basin and decreases to 2.1℃ at the higher (southern) part of the basin.

2.2. Data collection

Meteorological data (include precipitation, speed and direction of wind, wet and dry bulb temperature and evapotranspiration) were collected from 15 weather stations within and around the study area. Daily meteorological data are available for evaporation, precipitation, relative humidity, sunshine duration, average air temperature, minimum and maximum air temperature, wind speed in 2008. Evaporation observation equipment was sited above grass layer and surrounded by fallow soil. The location (latitude and longitude) for each station was measured using a global positioning system (GPS). 30 m resolution DEM was obtained from remote sensing laboratory of Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI), Chinese academy of sciences (CAS). The irrigation area for spring wheat was extracted from the land use classification map obtained from Landsat TM image (2000). The phenological information of spring wheat was collected from the Gansu Meteorological Bureau. The period of growing season at five typical stations in 2008 is different. the period was approximately estimated from the last 10 days of April to the first 10 days of July.

2.3. Calculation of the crop evapotranspiration

The crop evapotranspiration, ETc, is the product of reference crop evapotranspiration (ETo) and a crop coefficient (Kc) which is expressed as follows [2]:

$$\mathrm{ETc} = \mathrm{Kc} \cdot \mathrm{ET}_0 \tag{1}$$

where ETc denotes the crop evapotranspiration [mm d^{-1}], Kc, crop coefficient [dimensionless], and ET_0, reference crop evapotranspiration [mm d^{-1}].

Eight methods were used to calculate ET_0, including Penman–Monteith, Priestley-Taylor, Blaney-Criddle, Hargreaves, FAO-Radiation, Irmark-Allen, FAO-Penman and Penman. The root mean square error (RMSE) and coefficient of determination (R^2) were selected to evaluate each model's performance.

3. RESULTS

The performance of eight models at five stations changes greatly (Table 1). Table 1 shows Penman–Monteith model was the best-performed one and selected to calculate spatial distribution of $ET_{0.}$

According to investigation data and phenological data of spring wheat, Kc was estimated (e.g. Figure 1). Kc can be divided into four stages during growing season. Figure 1 shows the initial stable stage ended around 54 days after sowing, then followed by an increase stage of Kc from 54 to 81 days after sowing, during the period the value of Kc increase from 0.38 to 1.24, another stable stage existed from 81 to 106 days, finally, falling stage began from 106 days, Kc decreased from 1.24 to 0.5. ETc was calculated based on the equation (1) (Fig. 1).

Table 1 The coefficients of determination (R^2), and RMSE between estimated and observed ET_0 (daily) at five stations in 2008

Station	Gaotai	Zhangye	Minle	Linze	Shandan
Correlation coefficients（R^2）					
Penman–Monteith	0.842	0.824	0.966	0.965	0.743
Priestley-Taylor	0.688	0.710	0.874	0.878	0.612
Blaney-Criddle	0.474	0.469	0.712	0.639	0.554
Hargreaves	0.723	0.752	0.875	0.901	0.644
FAO-Radiation	0.492	0.543	0.580	0.677	0.539
Irmark-Allen	0.719	0.735	0.831	0.858	0.638
FAO-Penman	0.703	0.722	0.876	0.885	0.626
Penman	0.695	0.715	0.879	0.883	0.618
RMSE(mm)					
Penman–Monteith	1.27	1.59	2.58	3.29	1.72
Priestley-Taylor	7.25	6.94	4.93	4.62	6.44
Blaney-Criddle	11.66	11.46	7.43	9.71	9.23
Hargreaves	5.47	4.79	1.91	2.48	4.40
FAO-Radiation	3.52	3.61	4.43	4.53	3.51
Irmark-Allen	1.72	1.94	2.94	4.06	2.17
FAO-Penman	3.01	2.77	1.51	1.47	2.71
Penman	2.73	2.50	1.27	1.56	2.45

4. CONLUSIONS

In order to understand relationship between yield and water supply in arid-semiarid regions, actual crop evapotranspiration needs to be estimated. In this study, we focus on selection of optimum model for estimating ET_0, and then crop coefficient of spring wheat was calculated. Finally ETc of spring wheat was estimated in growing season at five stations of the study area. Some conclusions can be draw: 1) Penman–Monteith model performed extremely well in the arid area and the model can be selected to simulate the spatial distribution of ETc; 2) the study results can provide the baseline for future works related to the constitution of irrigation strategy, regional agriculture planning and management.

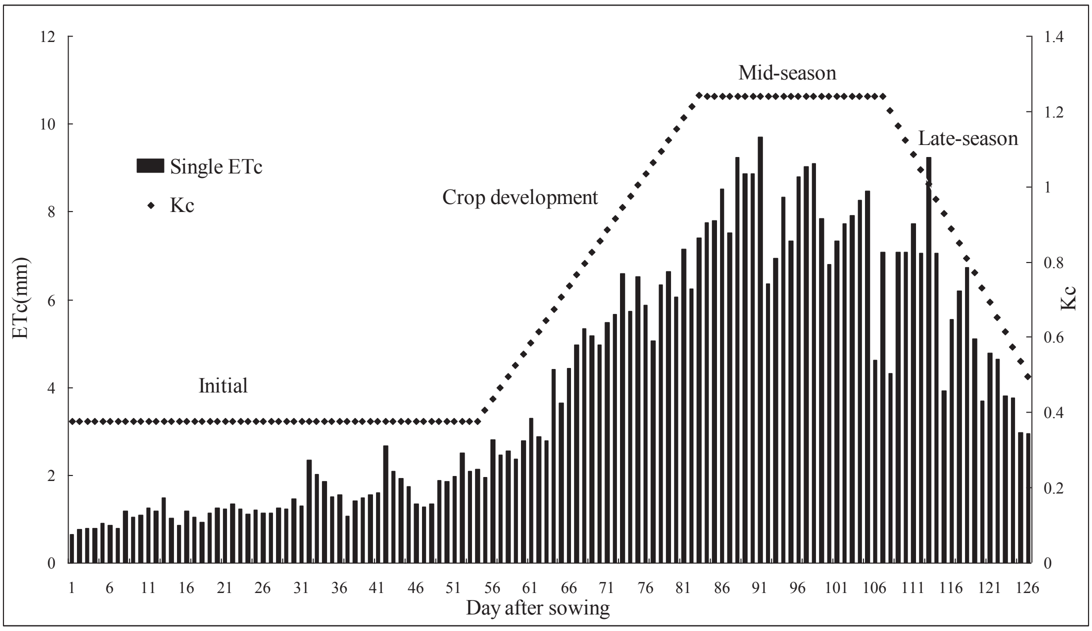

Fig. 1 The crop coefficient curve and actual crop evapotranspiration of spring wheat in different growing stage in Gaotai

5. REFERENCES

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