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Short communication

Modeling crop water requirement of grapes by using FAO-CROPWAT model in Quetta district, Balochistan

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Most of the countries of the world including Pakistan depend on ground water for irrigation. Pakistan is among the countries having acute water scarcity (Nasrullah *et al*., 2011). Agriculture is the sector which is influenced more by the water unavailability so more concern is required related to water (Kakar and Ahmad, 2016). Balochistan is one of the water scarce province of Pakistan, where the water table is decreasing at the rate of five meters per year thus affecting agriculture. The agriculture in Quetta is supported by the water from Pishin Lora Basin where water is declining due to growing high delta crops (Kakar and Ahmad, 2016). In Quetta district most of the fruits are produced including grapes, with total production of 7965 tonnes and covering 1596 hectares' area (Agriculture Statistics, Balochistan, 2014-15).

Modeling of crop water requirement (CWR) assists in water resource planning, regional drainage, effective irrigation scheduling and for determining potential for crop production. Depending on weather conditions a crop grown in different parts of the world have different crop water requirement whereas each crop grown in a specific area have their own crop water requirement.

The current study is carried out to compute CWR of grapes by using FAO-CROPWAT model (FAO 2009). The area selected was Quetta district of Balochistan is situated in north east at 30.1830° N latitude and 66.9987° E longitude. The total geographical area of the district Quetta is 2653 sq km, whereas the net cultivated area of the district is 11390 hectares which is 6.7 per cent of the total geographical area (Agriculture Statistics, Balochistan, 2014-15).

The crop water requirement (CWR) of grapes in the study area was determined by FAO CROPWAT 8.0 and CLIMWAT software's (FAO, 2004). For CWR the reference crop evapotranspiration ETo has been calculated by FAO Penman Monteith method in CROPWAT 8.0. The above mentioned software is based on FAO Irrigation and drainage paper 56 (FAO, 1998).

The crop evapotranspiration (ET_c) was calculated by reference crop evapotranspiration (ET_o) and crop coefficient (K_c) as shown in the following equation:

$$ET_c = ET_o \times K_c$$

Reference crop evapotranspiration was determined by Penman Monteith equation (Smith *et al*., 1992) given below:

$$ET_0 = \frac{0.408\,\Delta(R_n - G) + \gamma 900/(T+273)\,U_2\,(e_a - e_d)}{\Delta + \gamma(1 + 0.34U_2)}$$

In the above equation: ETo (mm day^{-1}) is reference evapotranspiration, R_n (MJ m^{-2} day^{-1}) is net radiation at the crop surface, G (MJ m^{-2} day^{-1}) is soil heat flux density, T (^oC) is average air temperature, U_2 (m/s) is wind speed at 2m height, e_a (kPa) is saturated vapour pressure, e_d (kPa) is actual vapour pressure, e_a- e_d (kPa) is saturated vapour pressure deficit, Δ (kPa/ ^oC) is slope vapour pressure curve, γ(kPa/ ^oC) is psychrometric constant.

Reference crop evapotranspiration (ETo)

Reference crop evapotranspiration in Quetta district ranged from 1.8-8.6 mm day^{-1}. It was lowest in January and highest in June as has been presented in Table 1. The average reference crop evapotranspiration was recorded to be 5.14 mm day^{-1} shown in Table 1. The results impersonated that in Quetta district ETo was

Table 1: Monthly ETo (mm day^{-1}) of Quetta district by FAO-CLIMWAT

Months	Jan	Feb	March	April	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
ETo	1.8	2.5	3.7	5.1	7.3	8.6	8.5	7.5	6.4	4.7	3.0	1.9	5.14

Table 2: ETo and climatic parameters (Correlation matrix)

Climatic parameters	Humidity	Wind	Sun hours	Radiation	Average Temp.	ETo
Humidity	1					
Wind speed	-0.08	1				
Sun shine hours	-0.69*	0.02	1			
Radiations	-0.76**	0.56	0.77**	1		
Average temperature	-0.76**	0.54	0.66*	0.94**	1	
ETo	-0.78**	0.56	0.72**	0.98**	0.99**	1

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed

Table 3: Crop evapotranspiration of grapes (developmental stages) in Quetta district

Stages	Kc Coefficient	ETc mm/day	ETc mm/dec
Initial	0.30	1.23	7.4
	0.30	2.61	26.1
Development	0.33	2.81	28.1
	0.84	6.37	63.7
Mid	0.93	6.72	73.9
	0.94	1.86	18.6
Late	0.92	1.78	19.6
	0.54	1.23	4.9
Total			1073.3 mm/dec

comparatively higher in dry season and lowest in rainy season. These results too appeared in conformity with that of earlier reported by Adeniral *et al.,* (2010).

Correlation study

Pearson product correlation coefficient was computed using SPSS version 20 for determining the relation of climatic parameters with ETo. The Correlation coefficient (r) values of ETo and climatic parameters have been given in Table 2. A strong positive correlation of ETo was observed with radiation, temperature, sun shine hours and wind speed as (r=0.98**), (r=0.99**), (r=0.72**) and (r= 0.56), respectively. ETo has also shown strong negative correlation (r= -0.78**) with humidity (Table 2). The positive correlation indicated increased ETo when the above mentioned parameters also increased whereas the negative correlation with humidity indicated inverse relation with ETo. In Quetta district, in the month of June the ETo was maximum (8.69 mm day^{-1}) when the humidity was lowest (42%); during all the months of the year.

Crop evapotranspiration (ETc)

The crop evapotranspiration (ET_c) varied in the initial, development, mid and late stages of crop growth as 7.4 to 26.1 mm/dec, 28.1 to 63.7 mm/dec, 73.9 to 18.6 mm/dec and 19.6 to 4.9 mm/dec, respectively. The ET_c value of grapes increased from initial to development stage, attained maximum in mid stage and started reducing in mid to late stages as shown in Table 3. The results showed that ET_c was higher when the rainfall was scarce whereas, it was lower in rainy season because of saturation of air. These results are in conformity with

Surendran *et al*., (2015). The crop water requirement of grapes determined through CROPWAT in Quetta district was 1073.3 mm/dec. Similarly, the total water requirement of maize was higher at Bharuch (520.5 mm) and lower at Khedbrahma (380.7 mm). Pandey *et al* (2008) reported water requirement of maize between (337 to 398 mm) in Narmada canal command area of Gujarat. Similar results have been reported by Kingra *et al.* (2004) in Punjab regions in India.

Crop water requirement (CWR) of grapes in Quetta district computed while using FAO CROPWAT Model based on Penman monteith equation and was 1073.3 mm/dec. ET_o ranged between 1.82 mm day^{-1} to 8.69 mm day^{-1} and was maximum in the month of June under low humidity/dry air conditions. The ET_c varied in initial, development, mid and late stages of crop growth as 7.4 to 26.1 mm/dec, 28.1 to 63.7 mm/dec, 73.9 to 18.6 mm/dec and 19.6 to 4.9 mm/dec, respectively. Through modeling of water requirement, water planning may be more effective in accordance with the climatic conditions and requirements for resilient agriculture.

Conflict of Interest Statement: The author(s) declare(s) that there is no conflict of interest.

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