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Evapotranspiration estimates and water balance of Kuwait

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ABSTRACT

Limited information exists on reliable estimates of evapotranspiration, to be used for developing scientific irrigation schedules and to achieve higher water use efficiency in the semi arid environments. The objective of the study is to estimate the reference crop evapotranspiration (ETo) and the water balance of Kuwait. The annual ETo of Kuwait is estimated as 2883mm. June, July are the months with highest evaporative demand and December and January are the months with lowest ETo. The total annual precipitation of Kuwait is 138.2mm of which 132.7mm (96 percent) forms effective. There is no rain during July, August, and September. Rain fed agriculture is rather difficult in the state of Kuwait. The annual water balance is -2744mm and the peak months of water deficit are June and July.

Key words: Weather, temperature, humidity, rainfall, potential evapotranspiration, climate

Reliable estimates of reference crop evapotranspiration (ETo) are required for efficient irrigation management. Water using efficiency in irrigated agriculture assumes greater significance particularly in semi arid environments with increasing pressure on water resources from competition users (Hatfield *et al.*, 1996). Kuwait is a small country of the Middle East with a geographical area of 17,818 square kilometer located at 30° 27' N, 48° 46' E. Large proportion of the land area is sandy deserts involving oil fields. Kuwait Institute of Scientific Research estimated that 2.71 percent of the lands of Kuwait are suitable for agriculture (KISR, 1999). In recent years agricultural activities are gaining momentum in this country.

There are different approaches in developing irrigation schedule. One method is the "water balance" or "soil water budget "approach which involves keeping an account of water input into the soil (rainfall and irrigation) and water output (evapotranspiration and drainage) on daily basis. Most water balance irrigation schedule methods are based on a daily estimate of the reference evapotranspiration (ETo) which is then modified according to the type of crop, stages of growth and soil water content (Hess,1996). A computer program or a spread sheet (Hess and Stephens, 1993) can be used to calculate ETo using the Penman or Penman- Monteith equation. In many parts of the world, irrigation is scheduled by use of a class 'A' evaporation pan (Doorenbos, 1976). But the

pan evaporation may be 25 to 100 percent more than ETo depending on location of the pan and the weather conditions. Hess (1996) reported that Penman-Monteith equation should give the best estimate of ETo where daily weather data are available. This method has been shown to be reliable in a wide range of environments (Allen *et.al.*, 1994).

Though several models have been proposed to predict ETo, there is no universal consensus on the suitability of any given model for a given climate, there by prompting (Smith *et al.*, 1996) to conclude that these models require rigorous local calibration before they can be used for the estimation of ETo for irrigation scheduling. The local calibration and validation are more important in semi-arid environments than the temperate, because almost all the ETo models were developed, calibrated, and validated for temperate environment using reliable and long term weather data (Ventura *et al.*, 1999, Allen *et al.*, 1998, Smith *et al.*, 1996 and Jensen *et al.*, 1990).

MATERIALS AND METHODS

Collection of climatic data

The climatic data of Kuwait such as air temperature (minimum and maximum), air humidity (morning and afternoon), rainfall, pan evaporation, wind speed and sunshine hours for the period 1962-2004 were collected from Kuwait International Airport and Kuwait Institute of Scientific Research (KISR, 1999). The mean weather data of 43 years were worked out and used for the estimation of reference crop evapotranspiration (ETo). The reference crop evapotranspiration was estimated following Penman-Monteith method using the FAO CROPWAT decision support system (Doorenbos and Pruit1977). The effective rain fall was estimated using USSCS formula as follows.

When Total rainfall < 250mm/month :
Effective rainfall = (125 – 0.2 * Total R.)* Total R / 125
& When Total R. > 250mm/month :
Effective rainfall = 0.1 * Total R. – 125

Water balance is estimated as the difference between total rain fall and ETo.

RESULTS AND DISCUSSION

Reference crop evapotranspiration (ETo)

The reference crop evapotranspiration calculated shows that the total annual ETo of Kuwait is about 2883mm (Table1). The highest monthly ETo values (421-422mm) were noticed during June and July (summer period). During this period, the temperature and wind speed. were considerably high compared to the other months. May to September forms the hot season (Salam and Mazrooe, 2006). The relative humidity were also very low during this period. The combined effect of high temperature, high wind speed and low relative humidity (May to October) caused a considerably high evaporative demand of the atmosphere and as such the ETo values were very high. The ETo values were lowest during the months of December and

Table 1 : Monthly ETo, rainfall and water balance of Kuwait (1962-2004)

Month	ETo	Rainfall	Effective Rainfall	Water balance
January	85	36.19	34.1	-85
February	108	13.09	12.8	-108
March	176	15.65	15.8	-176
April	236	11.33	11.1	-236
May	333	3.30	3.3	-333
June	421	0.25	0.3	-421
July	422	0.00	0.0	-422
August	384	0.00	0.0	-384
September	297	0.00	0.0	-297
October	206	4.60	4.6	-206
November	130	17.27	16.8	-130
December	86	36.58	34.5	-86
Total	2883	138.24	132.7	-2744

January coinciding with the cool season of Kuwait., This period correspond to the rainy season of the state. As such, the combined effect of low temperature, low wind speed, high humidity and rainfall might have been responsible for the low values of ETo during December and January.

Rainfall

The total annual rainfall of Kuwait is 138.2 mm. Scanty rainfall starts from October and the rainy period extends up to May. The peak rainy months are December (36.6 mm) and January (36.2 mm). During February, March and April small amounts of rainfall are being received (Table.1). In July, August and September, there is no rainfall at all. Rain-fed agriculture is difficult in Kuwait because of the extreme inadequacy of the rainfall

Effective rainfall

Of the total annual rain fall of 138.2mm, 132.7mm is effective. This works out to 96 percent of the total rain fall. The soils are generally sandy loam with low water holding capacity. As the quantum of rain fall is low, loss due to percolation and leaching may be minimum. As such, almost all the rain fall becomes effective and can contribute to the consumptive use of the crops and native vegetation.

Water balance

The monthly water balance of Kuwait is calculated as a difference between monthly precipitation and monthly ETo and presented in (Table 1). As such the annual water balance is -2744mm. Water deficit is highest during June, July and August. The reference crop evapotranspiration was also highest during

these months. An over view of the water balance data of Kuwait shows that there is not even a single month with surplus water. The data clearly indicates the extreme state of water deficit and aridity of the region. The results clearly indicate that it is difficult to resort to rainfed agriculture in Kuwait. There are opportunities for irrigated agriculture in Kuwait during the cool season (November to March). As this period coincide with the rainy season, part of the consumptive use requirement of the crop can be met from the rain fall as well.

During recent years, agricultural activities are in the course of development in Kuwait. Different types of agricultural crops are being grown both in the open and protected environments despite the harsh climate. Kuwait Institute of Scientific Research (KISR, 1999) reported that an area of 46,965 ha is suitable for irrigated agriculture, including open field, green house plantations, tree plantations and nurseries. Of this, only a small portion is presently utilised for cultivation. Most of the agricultural areas of Kuwait occur at Al-Abdali, Al-Wafra and along the south western margins of the Kuwait city. Date palm, potatoes and barley are the important crops grown in the open field under irrigated agriculture. Vegetables like cucumbers, tomatoes, okra, cauliflower, cabbage, lettuce, egg plant etc. are also grown in addition to cereals (wheat and maize) and forage crops. Attempts are meagre in the state of Kuwait to estimate the crop water requirements and irrigation water requirements of the crops. Growers are ignorant of scientific aspects of irrigation. The values of ETo estimated in the study can be successfully utilised for developing irrigation schedules for the crops of Kuwait. The information on water balance generated in the study will be useful for the water use planning of the state.

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