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Reference evapotranspiration and crop water requirement of apple (*Malus Pumila*) in Kashmir Valley

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ABSTRACT

Reference evapotranspiration is a significant agrometeorological parameter used for estimation of crop water requirement and irrigation scheduling. The present study was undertaken to determine the reference evapotranspiration and crop water requirement for apple cultivation in the Kashmir valley. Reference evapotranspiration (ET_0) was determined for seven major apple producing districts of Kashmir valley, viz. Srinagar, Budgam, Kupwara, Pulwama, Baramulla, Anantnag and Shopian. The average ET_0 for apples cultivation in Kashmir Valley was 912 mm. The mean water requirement (ET_c) was minimum during the initial stage being 69 mm and maximum during the mid-season stage being 668 mm. The mean water requirement during the late-season stage was 175 mm. The minimum annual ET_c was observed at Baramulla (846 mm) and the maximum annual ET_c at Srinagar (953 mm). Different stations showed variations in water requirement due to differences in altitude and local weather conditions.

Keywords: FAO Penman-Monteith method, reference evapotranspiration (ET_0), crop evapotranspiration (ET_c), apple

Apple is a rosaceous fruit tree, that belongs to genus Malus. It is the most widely grown fruit tree in the world and is propagated in temperate regions of both northern and southern hemispheres due to its high economic value. In India, the major apple producing regions include Kashmir, Himachal Pradesh, Uttar Pradesh, Kumaon, Assam and Nilgiri Hills. Apple is the principal fruit crop of Jammu and Kashmir and accounts for nearly 48 per cent of total area under all temperate fruits grown in the state. The annual apple production in the state is 1.7 million metric tons. Average yield of commercially important apple cultivars per unit area is the highest in the country ranging between 10-12 t ha^{-1}.

Weather conditions determine the water requirement of any crop (Ken *et al.,* 2012). For efficient irrigation water management in apple orchards, quantification of evapotranspiration is very important. Accurate estimation of evapotranspiration by field measurements is very difficult and time-consuming. Reference evapotranspiration ET_0 is estimated using empirical formulae based on meteorological data and is multiplied with crop coefficient to obtain crop evapotranspiration (Doorenbos and Pruitt 1977). The value of the crop coefficient depends on the type of crop, its stage of growth, canopy cover and crop density (Allen *et al.* 1998). In the present study, the reference evapotranspiration and the crop water requirement was estimated by means of FAO-56 Penman-Monteith Method (Allen *et al.,* 1998). The method has also been verified to be more suitable for Indian conditions than FAO-24 Penman method (Kashyap and Panda, 2001). The irrigation water use efficiency can be enhanced by the application of FAO-56 PM method and thus the distribution of water at different levels can be improved (Mehta and Pandey, 2015).

MATERIALS AND METHODS

The State of Jammu and Kashmir is located between 32°17' and of 37°5 North latitudes and 73°26' and 80°30' and 81° East longitudes. The state has a very rugged topography and consists of nearly 66 per cent of the mountainous area of India. Kashmir Valley is a temperate zone having 10 districts. The elevation varies from 1500 m amsl in the plain areas to 4200 m in upper reaches which are mostly snow bound. The weather data for the period 1992-2016 was obtained from Agro-Meteorological Field Unit (AMFU) Shalimar and Regional Meteorological Centre, Srinagar for seven major apple producing districts of Kashmir valley, viz. Srinagar, Budgam, Kupwara, Pulwama, Baramulla, Anantnag and Shopian.

FAO-56 Penman-Monteith method

The Penman-Monteith method also known as FAO-

Table 1: The monthly and annual values of ET_0 (mm) in seven districts of Kashmir Valley.

Month	Srinagar	Budgam	Kupwara	Pulwama	Baramulla	Anantnag	Shopian	Average
January	24.8	21.7	21.7	21.7	21.7	21.7	24.8	22.6
February	36.0	36.0	33.0	33.0	30.0	30.0	36.0	33.4
March	62.0	62.0	62.0	58.9	52.7	55.8	62.0	59.3
April	87.0	84.0	87.0	84.0	75.0	78.0	87.0	83.1
May	114.7	114.7	114.7	111.6	102.3	105.4	111.6	110.7
June	132.0	129.0	129.0	126.0	117.0	117.0	126.0	125.1
July	130.2	130.2	130.2	127.1	117.8	117.8	127.1	125.8
August	117.8	114.7	117.8	111.6	105.4	105.4	111.6	112.0
September	93.0	90.0	93.0	90.0	84.0	84.0	90.0	89.1
October	62.0	62.0	62.0	62.0	55.8	58.9	62.0	60.7
November	36.0	33.0	33.0	33.0	30.0	33.0	36.0	33.4
December	21.7	21.7	21.7	21.7	21.7	21.7	24.8	22.1
Annual Total	917.2	899.0	905.1	880.6	813.4	828.7	898.9	877.6

Table 2: Stage-wise and total water requirement of apple in different districts of Kashmir Valley.

Station	Initial Stage	Mid-season Stage	Late season Stage	Total
Srinagar	74	698	181	953
Ganderbal	72	687	176	935
Kupwara	70	694	178	943
Pulwama	68	672	176	916
Baramulla	63	621	163	846
Anantnag	65	628	168	861
Kulgam	74	676	181	931
Mean	69	668	175	912

56 Penman-Monteith method is given as:

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T_{mean}+273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)}$$

Where,

ETo = reference evapotranspiration [mm day^{-1}],

R_n = net radiation at the crop surface [MJ m-2 day^{-1}],

G = soil heat flux density [MJ m-2 day^{-1}],

Tmean = mean daily air temperature at 2 m height [°C],

Uz = wind speed at 2 m height [m s^{-1}],

es = saturation vapor pressure [kPa],

ea = actual vapor pressure [kPa],

es - ea = saturation vapor pressure deficit [kPa],

Δ = slope vapor pressure curve [kPa °C^{-1}],

γ = psychrometric constant [kPa °C^{-1}].

Crop coefficient (K_c)

The crop coefficient curve has three important stages *i.e.* initial stage ($K_{c\ ini}$), mid-season ($K_{c\ mid}$) and end stage ($K_{c\ end}$) respectively. The crop coefficient values used for the study were the FAO recommended values for the apple crop. The $K_{c\ ini}$ value for apple crop was taken as 0.6. The $K_{c\ mid}$ was 1.2 and the value of $K_{c\ end}$ was taken 0.85.

Crop water requirement (ET_c)

The crop water requirement was computed from reference evapotranspiration as per Doorenbos and Pruitt(1977):

$$ET_c = K_c X ET_0$$

Where,

ET_c = crop evaptranspiratin/crop water requirement (mm day^{-1}), ET_0 = reference evapotranspiration (mm day^{-1}), and K_c = crop coefficient.

The evapotranspiration was calculated on daily basis and then summed for different stages of growth and total water requirement of the apple crop.

RESULTS AND DISCUSSIONS

The monthly reference evapotranspiration (ET_0) in seven districts of Kashmir Valley presented in Table 1 shows

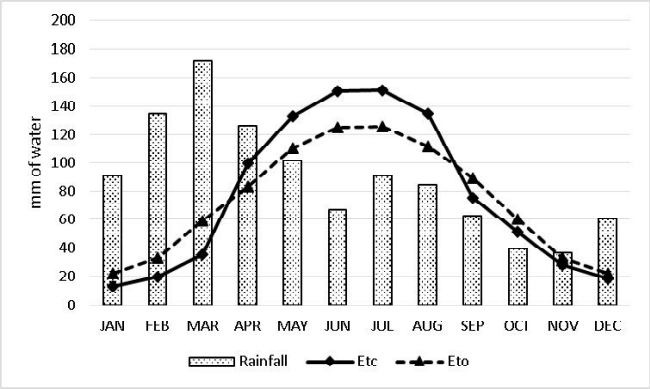

Fig. 1: Monthly variation of ET0 and ETc for Apple in Kashmir Valley

that ET_0 was minimum during December and January (21 to 25 mm) and maximum during June and July (117 to 173 mm) across the stations. The annual ET_0 was maximum (917.2 mm) at Srinagar and minimum (813.4 mm) at Baramulla with mean of 877.6 mm in Kashmir Valley.

The water required by the apple crop during initial, mid and late season of growth was minimum during the initial stage and maximum during mid-season stage. The water requirement was minimum in Baramulla district for all the stages with a total of 846 mm, while it was maximum in Srinagar district having a value of 953 mm (Table 2) with mean value of 912 mm for Kashmir Valley. The variation in water requirement in various districts is due to differences in altitude which varies from 1560-2020 m asl of these stations and local environment. Baramulla station due to its high altitude, more forest cover and rural vicinity has lesser evapotranspiration and thus lesser water requirement. Srinagar station on the other hand is located in urban area and has relatively less elevation than other stations. As such crop water requirement in this district is more than other districts.

The stage wise water requirement shows that during initial stage it was 69 mm, during mid-season stage was 668 mm and during late-season stage was 175 mm in Kashmir Valley as a whole. The water requirement was maximum during the mid-season stage comprising nearly 73 per cent of the total water requirement, while it was minimum during initial stage comprising only about 8% of the total water requirement.

The monthly variation of average rainfall, ET_0 and ET_c for the entire Kashmir valley is shown in Fig. 1. During the initial stage rainfall is high and the crop is in dormant stage, thus irrigation is not required during this period. However in the mid-season stage rainfall is very low as compared to the crop evapotranspiration. Efficient irrigation planning and scheduling is thus necessary during this period. The water requirement decreased progressively during the late season stage up to the end of the crop season. This season experiences sufficient rainfall to meet the requirement of crop evapotranspiration.

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