Journal of Agrometeorology 13 (2): 123-127 (Dec 2011)

Water requirement of pomegranate (*Punica granatum* L.) for Ahmednagar district of Maharashtra State, India

S.D.GORANTIWAR[1] D.T.MESHRAM[2] and H.K. MITTAL[3]

[1]*Department of Irrigation and Drainage Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra*

[2]*National Research Center on Pomegranate (ICAR), Solapur*

[3]*College of Tech and Enggineering, Udaipur*

Email: sdgorantiwar@gmail.com

ABSTRACT

The study was carried out to estimate reference crop evapotranspiration, develop crop coefficients and wetted area factors; and estimate crop evapotranspiration of pomegranate for Ahmednagar district of Maharashtra State. The crop coefficient values were estimated on weekly basis from the concept of shaded area that is widely used for the deciduous crops for the pomegranate plantation of 1st year to maturity (5th year) and are presented in the paper. Shaded areas were estimated at solar noon hour with the help of a specially prepared plywood board of different sizes with grid marking of size 20 x 20 cm for 5 randomly selected pomegranate trees each from 2 orchards of different ages. Pomegranate crop evapotranspiration was then determined on weekly basis. The values of water to be applied to pomegranate plantation spaced at 3 x 4.5 m and irrigated by the drip irrigation system of 90% efficiency were estimated and are presented in this paper for Ahmednagar district for 1st, 2nd, 3rd, 4th, and 5th years of pomegranate orchards for *Mrig, Ambhe* and *Hast Bahars*. The values of reference crop evapotranspiration, crop coefficient, area factor, water requirement and water to be applied presented in this paper would be useful for the appropriate irrigation water management of pomegranate.

Keywords: Pomegranate reference crop evapotranspiration, crop evapotranspiration, crop coefficient, wetted area factor, water requirement.

At present more than 1.25 lakh hectare area is grown under pomegranate in India; of which 0.87 lakh hectare area is in the state of Maharashtra alone. This state contributes more than 70% of the total area under pomegranate in India followed by Karnataka and Andhra Pradesh. Hence Maharashtra state is considered to be pomegranate basket of India. The productivity level of pomegranate is still low in India (<11.2 t ha^{-1}) compared to the major pomegranate producing countries like Israel, Iran, Morocco, Egypt, Afghanistan, Spain and Turkey (>40 t ha^{-1}). Pomegranate is largely cultivated in marginal lands with fertigation system and *bahar* treatment for regulating flowering and fruiting. Pomegranate is sensitive fruit crop to water stress. In Maharashtra pomegranate is predominately grown in the districts of Solapur, Ahmednagar, Pune, Nasik, Sangli, Satara and Osmanabad. Over 0.61 lakh hectares of pomegranate area is grown alone in Ahmednagar district. In these parts of Maharashtra, water is scarce commodity and hence there is a need to apply water according to water requirement of the crop. The water requirement of pomegranate crop depends on age, season, location and management strategies.

Computation of water requirement needs the measurement of evapotranspiration of the pomegranate (ETc). The ETc is estimated by multiplying reference crop evapotrasnpiration (ETr) with crop coefficient (Kc). Hence accurate estimation of ETr and Kc are of paramount importance for proper irrigation scheduling. Doorenbos and Pruitt (1977) defined the term reference crop evapotranspiration to avoid ambiguity involved in its interpretation as evapotranspiration of well watered, actively growing green grass which is clipped to uniform height 8-15 cm completely shading the soil, not short of water and covering an extensive area. Values measured or calculated at different locations or in different seasons are therefore comparable as they refer to the evapotranspiration from the same reference surface.

There are many methods reported in the literature to estimate ETr. The important methods include: Penman, Modified Penman, Penman Monteith, Hargreaves-Samani, FAO Pan Evaporation, Blanney-Criddle, FAO Radiation, Jensen-Haise, Priestly-Taylor, Thronthwaite and Christiansen (Michael, 2008 and Doorenbos and Pruitt, 1977). The Penman-Monteith method was found to be the appropriate method by these researchers and was also recommended by FAO for determining reference crop evapotranspiration.

The main objective of this paper is to present the values of water requirement (WR) of pomegranate during different weeks from their plantation for *Ahmednagar* district of Maharashtra. This required the determination of Kc and the estimation of ETr for Ahmednagar district. The paper presents the methodology used for determination of ETr, Kc, WR and weekly values of water requirement for the pomegranate tree

of different ages.

METHODOLOGY

Determination of crop coefficient (Kc) values

The Kc values vary with the growth stages and the age of the crop. In this study, the Kc values were developed with the help of shaded area approach that is adopted for many deciduous plantations. Ten commercial pomegranate orchards (*Mrig Bahar*) of 1to 5 year age (two each) were selected in 2008-09 and from each orchard 5 representative plants were randomly selected. It is stated here that the pomegranatge plantations of different ages were selected simultaneously for this study. The shaded area of each selected plant was measured at solar noon hour with the help of specially prepared plywood boards of 1.5x1.5, 2.5x2.5, 3.5x 3.5 m sizes with grid marking of size 20 x 20 cm. The shaded area was measured by measuring total numbers grids occupied by the area shaded by each plant on a weekly basis. The crop coefficient (Kc) was calculated by following equation, which was developed for deciduous fruit crops crop (Williams and Ayars, 2005).

$$Kc = 0.014x + 0.80 \qquad (R^2=0.95)$$

where, x = Percentage of shaded area, (%)

The week wise crop coefficient values were developed for different phenological stages i.e. new leaf initiation, crop development, crop maturity and crop harvesting for the orchards pruned in the month of June (*Mrig Bahar*) for the pomegranate orchards of 1 to 5 year age.

Estimation of ETr and ETc

The daily values of meteorological parameters were obtained from the Indian Meteorological Department, Pune for 33 years (1975-2007) for Ahmednagar district. The daily values of ETr were estimated for all years of available data following Penman-Monteith method (Allen *et al.* 1998) Weekly values of ETr and Kc were used to obtain weekly values of ETc (pomegranate crop evapotranspiration) by:

$$ETc = ETr * Kc$$

Water requirement

The water requirement (WR) by the surface irrigation methods is based on the estimated crop evapotranspiration (ETc). However water requirement by the drip irrigation method is less than the water requirement of the surface irrigation. Hence water requirement in case of drip irrigation method was estimated by.

$$WR = ETc * Fa$$

where Fa = Area factor (fraction) which is calculated as

$$Fa = \frac{shaded\ area\ (SA)}{area\ occupied\ by\ the\ tree}$$

RESULTS AND DISCUSSION

The average weekly ETr values estimated by Penman-Monteith method are presented in Fig. 1. It is revealed from figure that, ETr is the highest in May (19-20 MW) and lowest in the month of December (49-52 MW). The mean yearly value of reference crop evapotranspiration (ETr) as obtained by Penman-Monteith method is 1692.00 mm for Ahmednagar district of Mahrashtra state.

The weekly values of shaded area and crop coefficient were determined by using the procedures explained in the methodology section for *Mrig bahar* season for the pomegranate trees of different ages. According to different phenological stages of pomegranate, the period of new leaf initiation to 10 % ground cover of tree is 21 days, the crop development period i.e. up to 60 to 80 % ground cover of the tree is 77 days, the maturity period is 56 days and harvesting period is 105 days. It was found that the shaded area increases from new leaf initiation to maturity period from 0.64 to 10.62 m^2. During harvesting period shaded area decreases from 10.62 to 7.25 m^2 due to leaf drop, less application of irrigation water, removing of water sprout and harvesting of fruits. The weekly values of area factors were determined from the weekly values of shaded area and plant geometry. These values are presented in Table 1.

The weekly crop coefficient values of pomegranate tree of different ages for *Mrig bahar* season are shown in Fig. 2. It is seen from Fig. 2 that during the period from the new leaf initiation to crop development, the crop coefficient values increase from 0.22 to 1.10 and during maturity period, the Kc values are around 1.2. At harvesting, the value of Kc decrease from 1.14 to 0.65 due to leaf drop, removing of water sprout, foliage crumbling and harvesting of fruits.

The weekly crop coefficient values of pomegranate tree of different ages for *Mrig bahar* season shown in Fig. 2 can be used for the estimation of pomegranate crop evapotranspiration provided the values of ETr are known. The values of the weekly area factor shown in Table 1 for the pomegranate trees of different ages for *Mrig bahar* season can be used to estimate the water requirement for the pomegranate plantation irrigated by the drip irrigation method, once the

Table 1: Weekly values of area factor for pomegranate tree of different ages for *Mrig Bahar*

MW	Age of pomegranate tree					MW	Age of pomegranate tree				
	1st	2nd	3rd	4th	5th		1st	2nd	3rd	4th	5th
1	0.11	0.11	0.11	0.11	0.12	27	0.13	0.13	0.13	0.14	0.18
2	0.12	0.12	0.12	0.13	0.13	28	0.18	0.19	0.19	0.45	0.45
3	0.13	0.11	0.11	0.11	0.11	29	0.46	0.46	0.51	0.51	0.51
4	0.11	0.11	0.11	0.11	0.12	30	0.51	0.59	0.59	0.60	0.60
5	0.12	0.12	0.12	0.12	0.12	31	0.06	0.06	0.06	0.06	0.07
6	0.13	0.28	0.27	0.25	0.24	32	0.07	0.07	0.08	0.08	0.08
7	0.23	0.21	0.20	0.19	0.18	33	0.08	0.09	0.09	0.09	0.09
8	0.17	0.15	0.14	0.14	0.14	34	0.09	0.10	0.10	0.10	0.10
9	0.15	0.15	0.15	0.15	0.16	35	0.10	0.10	0.10	0.11	0.13
10	0.16	0.16	0.16	0.17	0.17	36	0.13	0.15	0.16	0.17	0.19
11	0.17	0.18	0.66	0.63	0.60	37	0.20	0.21	0.23	0.24	0.26
12	0.59	0.57	0.56	0.54	0.52	38	0.28	0.30	0.30	0.30	0.30
13	0.50	0.49	0.47	0.45	0.40	39	0.30	0.31	0.31	0.31	0.03
14	0.41	0.41	0.41	0.41	0.42	40	0.06	0.09	0.14	0.18	0.23
15	0.42	0.42	0.43	0.43	0.43	41	0.27	0.32	0.40	0.45	0.51
16	0.44	0.44	0.45	0.76	0.74	42	0.56	0.61	0.66	0.71	0.71
17	0.72	0.70	0.69	0.68	0.67	43	0.71	0.71	0.71	0.71	0.71
18	0.65	0.64	0.63	0.60	0.53	44	0.72	0.04	0.09	0.13	0.17
19	0.53	0.53	0.54	0.54	0.54	45	0.21	0.27	0.32	0.39	0.45
20	0.54	0.56	0.56	0.56	0.57	46	0.50	0.56	0.62	0.67	0.73
21	0.57	0.57	0.58	0.58	0.74	47	0.76	0.76	0.76	0.77	0.77
22	0.72	0.69	0.67	0.66	0.63	48	0.77	0.77	0.78	0.05	0.10
23	0.61	0.60	0.57	0.56	0.54	49	0.15	0.21	0.26	0.30	0.36
24	0.46	0.47	0.47	0.47	0.48	50	0.42	0.47	0.53	0.57	0.62
25	0.48	0.48	0.48	0.49	0.49	51	0.67	0.73	0.78	0.78	0.78
26	0.49	0.49	0.50	0.50	0.50	52	0.78	0.78	0.79	0.79	0.79

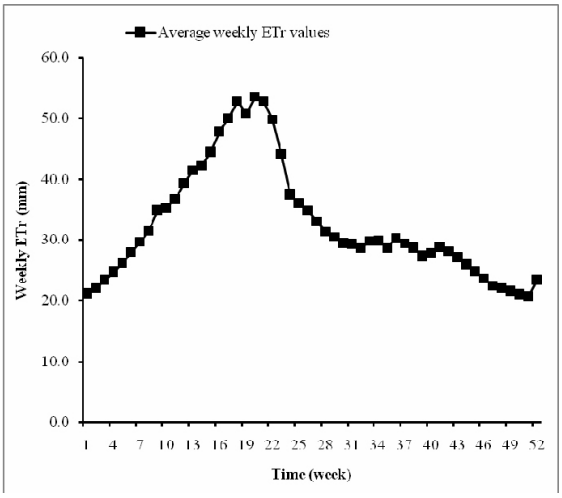

Fig. 1: Average weekly ETr values for Ahmednagar district

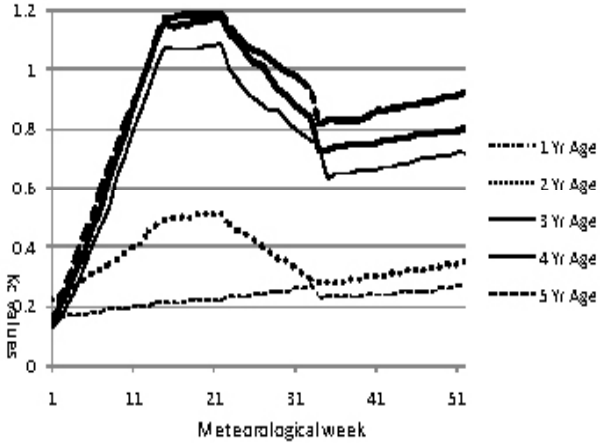

Fig. 2: Crop coefficient (Kc) values of pomegranate of 1 to 5 year age for *Mrig Bahar*

values of pomegranate crop evapotranspiration are estimated. The water requirement for the pomegranate plantation of different ages estimated by using the area factor, crop coefficient and reference crop evapotrasnpiration are presented in Table 2. The shaded portion in the table shows the period during which the pomegranate orchrd needs to be provided with the water stress for the management purpose. This period is 1 month in the table. However this period can

Table 2: Water requirement (mm) of pomegranate tree of different ages for *Mrig Bahar* season

MW	Age of pomegranate tree					MW	Age of pomegranate tree				
	1st	2nd	3rd	4th	5th		1st	2nd	3rd	4th	5th
1	0.8	1.6	1.2	1.7	2.1	27	1.8	4.4	12.6	18.1	23.0
2	0.8	1.7	1.6	2.4	3.3	28	1.7	4.0	11.5	16.7	21.4
3	0.9	2.0	2.2	3.3	4.5	29	1.7	3.7	10.8	15.8	20.6
4	0.9	2.2	3.0	4.5	6.1	30	1.7	3.4	9.9	14.7	19.5
5	1.0	2.5	3.8	5.6	7.6	31	1.7	3.2	9.6	14.1	19.1
6	1.1	2.8	4.9	7.1	9.3	32	1.7	3.0	9.0	13.3	18.3
7	1.2	3.2	6.3	8.9	11.6	33	1.8	2.8	9.1	13.2	18.2
8	1.3	3.6	7.8	10.8	13.9	34	1.5	2.8	8.7	12.8	16.3
9	1.5	4.2	9.9	13.7	17.3	35	1.5	2.7	8.2	11.6	15.7
10	1.5	4.4	11.3	15.3	19.3	36	1.5	2.8	8.6	12.4	16.6
11	1.6	4.9	12.9	17.8	21.6	37	1.5	2.8	8.5	12.1	16.2
12	1.7	5.4	15.1	20.7	24.9	38	1.5	2.7	8.3	11.8	15.8
13	1.9	6.2	17.1	23.5	28.2	39	1.4	2.7	7.9	11.3	15.1
14	1.9	6.7	18.9	25.3	31.2	40	1.5	2.7	8.1	11.6	15.5
15	2.1	7.3	21.1	28.2	34.7	41	1.5	2.8	8.5	12.0	16.4
16	2.3	7.9	22.7	30.4	37.4	42	1.5	2.8	8.3	11.8	16.1
17	2.4	8.3	23.7	31.8	39.2	43	1.5	2.7	8.1	11.6	15.6
18	2.6	8.9	25.2	33.6	41.5	44	1.4	2.7	7.8	11.2	15.1
19	2.5	8.6	24.2	32.3	39.9	45	1.4	2.6	7.5	10.7	14.5
20	2.6	9.1	25.7	34.1	42.1	46	1.3	2.5	7.2	10.2	13.9
21	2.6	9.0	25.4	33.6	41.6	47	1.3	2.4	6.9	9.7	13.3
22	2.5	8.5	23.9	31.7	39.2	48	1.2	2.4	6.8	9.6	13.1
23	2.2	6.9	20.2	27.5	33.6	49	1.2	2.4	6.7	9.4	12.9
24	1.9	5.7	16.4	22.7	27.9	50	1.2	2.4	6.6	9.2	12.7
25	1.9	5.2	15.1	21.1	26.1	51	1.2	2.3	6.6	9.1	12.9
26	1.8	4.9	13.9	19.7	24.6	52	1.4	2.7	7.5	10.3	14.4
						Total	83.9	216.1	593.1	821.7	1051.1

be up to 2 months depending on the climate and soils. After the stress period is over, it is necessary to bring the moisture content in the root zone to the field capacity. For this purpose, it is proposed to operate the drip irrigation sysem continuously for 24 to 48 hours.

The water to be applied to the pomegranate plantation irrigated by surface irrigation methods can be calculated by using the ETr values (Fig. 1) and Kc values (Fig. 2), if the efficiency of the surface irrigation method is known. The water to be applied to the pomegranate plantation irrigated by drip irrigation method can be calculated by using the water requirement values (Table 2), if the efficiency of the drip irrigation method and the area covered by the pomegranate tree are known. Thus the values of area factor and crop coefficnet developed in this study and presented in this paper would be useful for irrigation scheduling of pomegranate by drip and surface irrigation methods.

CONCLUSIONS

The Penman-Monteith method which is recommended by the FAO is the most accurate method for the estimation of reference crop evapotranspiration as evidenced from the literature. However, this method needs the large amount of data. The values of reference crop evapotranspiration that were estimated by the Penman-Monteith method and presented in this paper on weekly basis for the Ahmednagar district would be useful to estimate the crop evapotranspiration, if the values of crop coefficient are known. The crop coefficient values of pomegranate trees of 1st year to maturity would be useful to estimate the crop evapotranspiration of pomegranate. The area factor values developed in this study would be useful to estimate the water requirement of pomegranate trees of different ages in combination with the crop coefficient values. The values of water to be applied to pomegranate (spaced at 3 x 4.5 m) irrigated by drip irrigation method of efficienc of 90% on weekly basis for Ahmednagar district in Maharashtra State would be useful for irrigation planning and optimum and efficient utilization of irrigation water for pomegranate

orchards.

REFERENCES

Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. (1998). "Crop Evapotranspiration, Guideline for Computing Crop Water Requirements". FAO Irrigation and Drainage Paper 56. FAO Rome, Italy, pp. 300.

Doorenbos, J. and Pruitt, W. O. (1977). "Guidelines for Predicting Crop Water Requirement". FAO Irrigation and Drainage Paper No. 24, FAO, Rome, Italy, pp.156.

Michael, A. M. (2008). Irrigation: Theory and Practice. Vikas Publication, New Delhi, pp.509.

Mohan, S. (1991). Inter Comparison of Evapotranspiration estimates. Hyd. Sci. J., 366:447 - 460

William, L. E. and Ayars, J. E. (2005). Grapevine water use

Received: January 2011; Accepted: July 2011