Water requirement of pomegranate (*Punica granatum* L.) orchards for season August-March (*Mrig bahar*)

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■ **ABSTRACT :** Pomegranate evapotranspiration determined by the effects of various weather conditions were incorporated into reference crop evapotranspiration and crop characteristics into crop co-efficient. The average ETr values over the 31 years were determined by Penman-Monteith method. The probability distributions that were fitted to ETr values are Log normal, Gumbel and Weibull's probability distribution functions. Chi-square test was performed to know the probability distribution of best fit. ETr values at 10 per cent to 90 per cent probability level for Penman-Monteith method using probability distribution of best fit. The values of reference crop evapotranspiration, crop co-efficient, area factor, water requirement and water to be applied would be useful for the irrigation water management of pomegranate. The water was applied through drip system at 90 per cent efficiency to pomegranate plantation spaced at 3 × 4.5 m. The result reveals, for *Mrig bahar* the total weekly water to be applied to pomegranate tree at 70 per cent probability level for 1ˢᵗ to 5ᵗʰ year was 112.44, 303.08, 761.64, 1058.5 and 1327.4 lit/year/tree, respectively.

■ **KEY WORDS :** Reference crop evapotranspiration (ETr), Crop co-efficient (kc), Pomegranate evapotranspiration (ETp), *Mrig bahar*, Water requirement

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T he total pomegranate production in the world is 1.15 MT out of which India produce 0.5 MT. (Holland *et al.,* 2009). India over 0.13 Mha areas is under pomegranate of which 0.098 Mha area is in Maharashtra, producing about 85 per cent of total Indian production and Solapur district is having large area under pomegranate orchards (Jadhav, 2011). But the productivity in India is still low (<6.7 t/ha) as compared to the major pomegranate producing countries like Israel, Iran, Morocco, Egypt, Afghanistan, Spain, Turkey, China, Greece, Japan, France and Italy (>40 t/ha) (Holland and Bar-Ya'akov, 2008). In the pomegranate growing area of Maharashtra, water is scarce resources and there is a need to investigate actual water requirement of

pomegranate trees. Knowledge of evapotranspiration is essential for efficient management of water resource, crop production and environment assessment. It further continues to be foremost important in water resource planning and management.

In concern with pomegranate orchard, in Maharashtra *Bahar* is a local word also widely used to express flowering seasons of horticulture crop, here *bahar* word taken as flowering seasons of pomegranate. Thus, flowering seasons are defined as: *Ambe bahar* flowering period (January - February) and harvesting period (June-July), *Mrig bahar* flowering period (June-July) and harvesting period (December-January) and *Hasta bahar* flowering period (September-October) and

harvesting period (January-February) (NRCP, 2009). The crop co-efficient values are influenced by local climatic condition and need to be measured locally. Therefore, in this study, the crop co-efficient values of the pomegranate crop under consideration have been estimated from the measurements of shaded area of pomegranate orchards at solar noon hour for Solapur (Meshram *et al.*, 2010). Water requirement of pomegranate *bahar* is estimated for *Mrig bahar*.

Probability distribution function :

The irrigation planning based on the probabilistic approach, for this purpose it is necessary to know the ETr values at the different probability levels. Therefore, it is essential to know the probability distribution of ETr. In addition to this, probability analysis can be used for prediction of occurrence of future events from available records. Therefore, in this study, it is planned to fit the three probability distribution functions to ETr data. The probability distributions that were used for reference crop evapotranspiration data were logged normal, Gumbel and Weibull's. The Chi-square test of goodness of fit was used to select best fit distribution.

Data collection :

Meteorological data :

Daily parameters (*i.e.* maximum temperature (T_{max}, ^{0}C) and minimum temperature (T_{min}, ^{0}C), maximum relative humidity (RH_{max}, %) and minimum relative humidity (RH_{min}, %), pan evaporation (E_{pan}, mm), wind speed (WS, kmhr^{-1}) at height of 2.0 m, sun shine hours (SSHr, hr), rainfall (R, mm) etc.) were collected from Indian Meteorological Department, Pune. Kc values were taken from Ph.D. Thesis, submitted at College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur (Meshram *et al.,* 2010).

■ METHODOLOGY

Estimation of reference crop evapotranspiration (ETr) :

The weekly reference crop evapotranspiration was estimated by using the standard method *i.e.* Penman-Monteith (Allen *et al.,* 1998).

$$ETr = \frac{0.408 \ \Delta (R_n - G) + \Gamma \left(\dfrac{900}{T + 273}\right) u_2 \ (e_s - e_a)}{\Delta + \Gamma (1 + 0.34 \, u_2)} \quad .....(1)$$

where,

ETr = Reference crop evapotranspiration (mm/day),

G = Soil heat flux density (MJ/m^2/day),

R = Net radiation (MJ/m^2/day),

T = Mean daily air temperature (^{0}C),

Γ = Psychometric constant (kPa/^{0}C),

Δ = Slope of saturation vapour pressure function (kPa/^{0}C),

e_s = Saturation vapour pressure at air temperature T (kPa),

e_a = Actual vapour pressure at dew point température (kPa),

u_2 = Average daily wind speed at 2 m height (m/sec).

Probability distribution functions :

Gumbel distribution :

$$f(x) = \frac{e^{-\frac{(x - \gamma)}{\beta}} e^{-e^{-\frac{(x - \gamma)}{\beta}}}}{\beta} \quad .....(2)$$

where,

X = Variate of the sample

β = Scale parameter

γ = Location parameter.

Weibull (Maxima) distribution :

$$f(x) = \frac{\alpha}{\beta}\left(\frac{\gamma - x}{\beta}\right)^{\alpha - 1} e^{-\left(\frac{\gamma - x}{\beta}\right)^{\alpha}} \quad ....(3)$$

where,

α = Shape parameter

β = Scale parameter

γ = Location parameter

X = Variable of the sample.

Log normal distribution :

$$f(x) = \frac{1}{x\sqrt{2\pi\sigma^2}} e^{-\frac{(\ln x - \mu)^2}{2\sigma^2}} \quad ....(4)$$

where,

X = Variable of the sample

μ = Population mean

σ = Standard deviation.

Test for goodness of fit of probability distributions:

Chi-square test was used for testing goodness of fit test.

$$x^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad \quad ....(5)$$

where,
k = Number of years
O_i = Observed values in i^{th} year
E_i = Expected value in i^{th} year.

Selection of best fit distribution :

For each week different probability distribution functions were tested using Chi-square test. In this, calculated Chi-square value was compared with table value and observed the significance at 5 per cent level of significance. If the calculated Chi-square value was found less than the table value, that distribution for respective week was considered as non-significant. If more than one distribution was found fit for all weeks or months, then distribution with lowest Chi-square value were selected as best fit distribution for respective week. Out of these, the distribution best fit for more number of weeks was selected to determine the expected reference evapotranspiration rate at 10, 20, 30, 40, 50, 60, 70, 80, and 90 per cent probability levels for each week. The data were analyzed by VTFIT software. VTFIT happens to be a routine for fitting homogeneous probability density functions (PDFs) which fits PDFs to data by maximum likelihood method. The VTFIT package used for fitting probability functions that provide goodness of fit tests and expected values.

Crop co-efficient (Kc) :

The weekly crop co-efficient values were used for different phenological stages *i.e.* new leaf initiation, crop development, crop maturity and crop harvesting (Meshram *et al.*, 2010).

Pomegranate evapotranspiration (ETp) :

The weekly values of ETr and Kc were used to obtain weekly values of ETp by equation for *Mrig bahar*

ETp = ETr× kc × Crop spacing × Wetted area
× Water application efficiency ....(6)

where,
ETp = Pomegranate evapotranspiration (mm/day)
ETr = Reference crop evapotranspiration (mm/day)
Kc = Crop co-efficient of pomegranate
Wetted area = 20 per cent of crop spacing
Water application efficiency = 90 per cent (for drip system).

■ **RESULTS AND DISCUSSION**

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Estimation of ETr values at different probability levels :

ETr values at different probability levels *viz.,* 10, 20, 30, 40, 50, 60, 70, 80 and 90 per cent were estimated by using these best probability distribution functions for
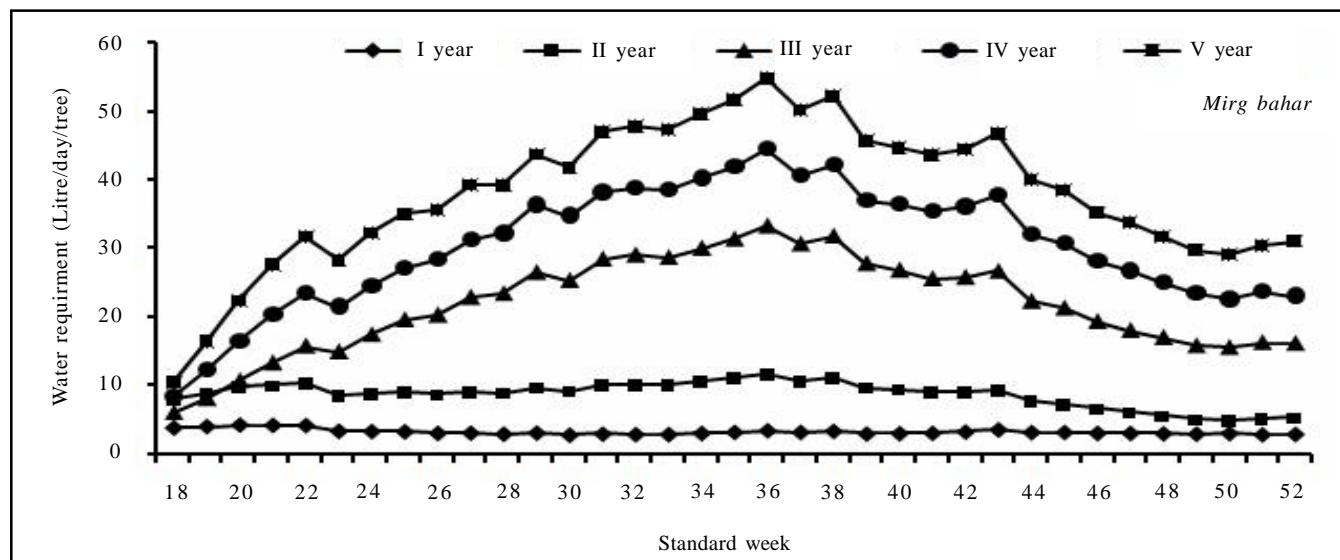

Fig. 1 : Water requirement of pomegranate orchards for Ist to 5th year's tree at 70 per cent probability level

all the weeks. In case of more than one distribution is the best fit, the distribution selected for estimating ETr values was in order of Log normal, Gumbel and Weibull's (Meshram, 2010a). As more than one distribution fits many weeks, the best distribution for such week was considered as the distribution that gives the lowest values of Chi-square at 5 per cent level of significance. For

Mrig bahar, Log normal distribution is the best fit for maximum weeks (24), followed by Gumbel (7) and Weibull's (3). The values of ETr by Penman-Monteith method at different probability levels for Solapur for all the weeks are shown in Table 1.The per cent values of water requirement determined with the help of VTFIT software and values at 70 per cent probability is taken

SMW	Distribution	10%	20%	30%	40%	50%	60%	70%	80%	90%
18	Log normal	46.2	48.3	49.8	51.2	52.5	53.9	55.4	57.2	59.8
19	Log normal	46.4	48.9	50.7	52.4	54.0	55.6	57.4	59.6	62.8
20	Log normal	46.5	49.4	51.6	53.6	55.5	57.5	59.7	62.3	66.2
21	Log normal	43.5	46.6	48.9	51.0	53.0	55.2	57.5	60.4	64.7
22	Log normal	39.4	42.9	45.7	48.1	50.6	53.1	56.0	59.5	64.9
23	Weibulls	30.0	33.4	35.8	37.8	39.8	41.7	43.7	45.9	48.9
24	Log normal	29.6	32.3	34.4	36.3	38.2	40.2	42.4	45.1	49.2
25	Log normal	28.3	30.9	33.0	34.9	36.7	38.6	40.8	43.5	47.6
26	Log normal	25.6	28.1	30.0	31.7	33.4	35.2	37.2	39.8	43.6
27	Log normal	26.7	28.9	30.6	32.1	33.6	35.2	37.1	39.2	42.5
28	Log normal	23.6	25.8	27.6	29.3	30.9	32.5	34.5	36.8	40.4
29	Gumbel	21.1	25.7	28.5	30.6	32.5	34.1	35.8	37.5	39.7
30	Log normal	22.6	24.6	26.1	27.4	28.8	30.2	31.7	33.7	36.6
31	Log normal	21.6	24.0	25.8	27.5	29.2	30.9	32.9	35.5	39.3
32	Gumbel	22.6	24.6	26.1	27.4	28.8	30.2	31.7	33.7	36.6
33	Log normal	23.1	24.8	26.2	27.5	28.7	29.9	31.3	33.1	35.6
34	Gumbel	19.4	23.5	26.1	28.0	29.7	31.2	32.7	34.3	36.3
35	Log normal	22.2	24.6	26.6	28.3	30.1	32.0	34.1	36.8	40.9
36	Gumbel	17.7	23.4	27.0	29.7	32.0	34.1	36.2	38.4	41.1
37	Log normal	23.7	25.7	27.2	28.7	30.0	31.5	33.1	35.1	38.1
38	Gumbel	21.0	25.1	27.7	29.7	31.3	32.9	34.3	35.9	37.8
39	Log normal	23.2	24.7	25.8	26.9	27.9	28.9	30.0	31.5	33.6
40	Log normal	22.4	24.1	25.4	26.6	27.8	29.0	30.4	32.0	34.5
41	Log normal	22.0	23.8	25.2	26.5	27.7	29.0	30.4	32.2	34.8
42	Gumbel	17.1	21.7	24.6	26.8	28.6	30.3	32.0	33.8	36.0
43	Weibulls	27.2	28.6	29.8	30.9	31.9	33.2	34.6	36.3	39.1
44	Log normal	22.3	24.0	25.3	26.5	27.7	28.9	30.2	31.9	34.3
45	Log normal	23.1	24.6	25.8	26.8	27.8	28.8	29.9	31.3	33.4
46	Weibulls	20.5	22.5	23.9	25.1	26.1	27.2	28.2	29.4	30.8
47	Log normal	21.2	22.6	23.7	24.7	25.6	26.6	27.7	29.0	31.0
48	Log normal	20.3	21.7	22.8	23.8	24.7	25.7	26.8	28.1	30.1
49	Log normal	20.4	21.6	22.6	23.4	24.2	25.0	26.0	27.1	28.7
50	Log normal	20.8	22.0	22.9	23.8	24.6	25.4	26.3	27.4	29.1
51	Log normal	24.2	25.2	26.0	26.7	27.3	28.0	28.7	29.6	30.9
52	Gumbel	23.1	25.1	26.2	27.1	27.9	28.6	29.2	30.0	30.9

Table 1 : Weekly ETr values for *Mrig bahar* at different probability levels by using best fit probability distribution functions

as most reliable (Meshram *et al.,* 2010). The values calculated with the starting of *Mrig bahar* means 18th standered meteorological week (SMW) and end on 52nd standered meteorological week. Weekly values of pomegranate evapotranspiration (ETp) at different probability levels are presented in Tables 2 to 6 for 1st to 5th year's tree for *Mrig bahar* of 35 crop weeks of phenological development stages for Solapur district and water requirement of pomegranate orchards for 1st to 5th year's tree at 70 per cent probability level shown in Fig. 1.

Table 2 : Pomegranate evapotranspiration (ETp) of *Mrig bahar* (lit/day/tree) for 1st year pomegranate tree at different probability levels									
SMW	Probability levels								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
18	3.18	3.33	3.44	3.53	3.63	3.72	3.82	3.95	4.13
19	3.25	3.42	3.55	3.67	3.78	3.90	4.02	4.18	4.40
20	3.32	3.52	3.68	3.82	3.96	4.10	4.26	4.45	4.73
21	3.17	3.40	3.57	3.72	3.87	4.02	4.20	4.41	4.72
22	2.94	3.20	3.41	3.59	3.78	3.96	4.18	4.44	4.84
23	2.29	2.55	2.73	2.89	3.04	3.18	3.33	3.51	3.73
24	2.30	2.51	2.68	2.82	2.97	3.12	3.29	3.51	3.83
25	2.26	2.47	2.64	2.79	2.93	3.08	3.26	3.48	3.80
26	2.08	2.28	2.43	2.57	2.71	2.86	3.02	3.23	3.54
27	2.20	2.38	2.53	2.65	2.78	2.91	3.06	3.24	3.51
28	1.99	2.18	2.33	2.47	2.60	2.75	2.91	3.11	3.41
29	1.81	2.20	2.44	2.62	2.78	2.92	3.07	3.21	3.40
30	1.97	2.14	2.27	2.39	2.50	2.63	2.76	2.93	3.19
31	1.91	2.12	2.29	2.43	2.58	2.74	2.91	3.14	3.47
32	2.02	2.20	2.33	2.46	2.58	2.70	2.84	3.02	3.28
33	2.09	2.26	2.38	2.49	2.60	2.72	2.85	3.00	3.24
34	1.78	2.16	2.40	2.58	2.73	2.87	3.01	3.15	3.33
35	2.06	2.29	2.47	2.64	2.80	2.98	3.18	3.42	3.81
36	1.67	2.20	2.54	2.80	3.01	3.21	3.41	3.61	3.87
37	2.27	2.46	2.61	2.74	2.87	3.01	3.17	3.36	3.65
38	2.04	2.43	2.68	2.87	3.03	3.18	3.32	3.47	3.66
39	2.26	2.41	2.52	2.62	2.72	2.82	2.93	3.07	3.28
40	2.20	2.37	2.49	2.61	2.73	2.85	2.99	3.14	3.39
41	2.20	2.38	2.52	2.64	2.76	2.89	3.04	3.21	3.48
42	1.72	2.18	2.47	2.69	2.87	3.05	3.21	3.39	3.61
43	2.77	2.92	3.04	3.15	3.26	3.39	3.53	3.71	3.99
44	2.31	2.49	2.63	2.75	2.87	3.00	3.14	3.31	3.56
45	2.44	2.60	2.72	2.83	2.94	3.04	3.16	3.30	3.53
46	2.20	2.41	2.56	2.69	2.80	2.91	3.02	3.15	3.30
47	2.31	2.46	2.58	2.69	2.79	2.90	3.02	3.16	3.38
48	2.24	2.40	2.52	2.63	2.73	2.84	2.96	3.11	3.33
49	2.28	2.42	2.52	2.62	2.71	2.80	2.91	3.03	3.22
50	2.36	2.50	2.61	2.70	2.79	2.89	2.99	3.12	3.30
51	2.37	2.47	2.54	2.61	2.67	2.74	2.81	2.90	3.02
52	2.27	2.46	2.58	2.66	2.74	2.81	2.87	2.95	3.03
(l/y/tree)	80.5	88.17	93.7	98.4	103	107	112	118	127

1st year :

Weekly values of pomegranate evapotranspiration (ETp) for *Mrig bahar* at different probability levels are presented in Table 2 for 1st year tree. It is observed from the table that, at 70 per cent probability level weekly

pomegranate evapotranspiration (ETp) ranged from 2.76 to 4.26 lit/day/tree. Maximum values of pomegranate evapotranspiration (ETp) were observed in 20th weeks. These values were 4.45, 4.26, 3.96 and 3.52 lit/day/tree at probability levels 80 per cent, 70 per cent, 50 per cent

SMW	Probability levels								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
18	6.61	6.91	7.13	7.33	7.52	7.72	7.93	8.19	8.56
19	7.11	7.50	7.78	8.04	8.28	8.54	8.81	9.15	9.64
20	7.61	8.09	8.45	8.78	9.09	9.41	9.77	10.2	10.85
21	7.52	8.05	8.45	8.81	9.16	9.53	9.94	10.4	11.17
22	7.24	7.89	8.40	8.84	9.30	9.76	10.3	10.9	11.93
23	5.90	6.55	7.03	7.43	7.81	8.18	8.57	9.02	9.60
24	6.13	6.69	7.13	7.52	7.91	8.32	8.77	9.34	10.20
25	6.21	6.78	7.24	7.66	8.05	8.47	8.95	9.55	10.44
26	5.94	6.50	6.95	7.35	7.74	8.16	8.63	9.22	10.10
27	6.46	7.00	7.41	7.79	8.16	8.54	8.99	9.50	10.29
28	6.06	6.64	7.10	7.52	7.93	8.37	8.86	9.47	10.39
29	5.71	6.93	7.68	8.27	8.76	9.21	9.66	10.1	10.71
30	6.49	7.05	7.48	7.87	8.26	8.66	9.11	9.67	10.51
31	6.58	7.30	7.86	8.37	8.87	9.41	10.0	10.7	11.94
32	7.19	7.81	8.29	8.72	9.15	9.60	10.1	10.7	11.64
33	7.38	7.95	8.39	8.79	9.17	9.57	10.0	10.6	11.40
34	6.24	7.57	8.40	9.03	9.57	10.0	10.5	11.0	11.69
35	7.18	7.98	8.60	9.18	9.76	10.4	11.0	11.9	13.25
36	5.70	7.52	8.67	9.54	10.3	10.9	11.6	12.3	13.21
37	7.61	8.26	8.76	9.21	9.65	10.1	10.6	11.3	12.24
38	6.76	8.08	8.90	9.53	10.0	10.5	11.0	11.5	12.16
39	7.44	7.93	8.31	8.64	8.96	9.29	9.66	10.1	10.78
40	6.91	7.44	7.84	8.21	8.58	8.95	9.38	9.87	10.65
41	6.51	7.05	7.46	7.83	8.19	8.57	9.00	9.52	10.30
42	4.79	6.08	6.89	7.50	8.03	8.51	8.98	9.48	10.09
43	7.33	7.72	8.04	8.33	8.62	8.95	9.33	9.81	10.56
44	5.72	6.15	6.49	6.80	7.09	7.40	7.75	8.17	8.80
45	5.63	6.00	6.29	6.53	6.78	7.02	7.29	7.63	8.14
46	4.79	5.25	5.57	5.84	6.09	6.33	6.57	6.84	7.17
47	4.62	4.94	5.18	5.39	5.60	5.81	6.05	6.34	6.77
48	4.18	4.46	4.69	4.90	5.08	5.29	5.51	5.78	6.19
49	3.93	4.17	4.35	4.51	4.67	4.83	5.01	5.22	5.54
50	3.81	4.04	4.21	4.36	4.51	4.67	4.83	5.04	5.34
51	4.32	4.50	4.64	4.76	4.88	5.00	5.13	5.29	5.51
52	4.16	4.51	4.71	4.87	5.01	5.13	5.26	5.39	5.55
(l/y/tree)	213	235	250	264.1	276	289	303	319	343.3

Table 3: Pomegranate evapotranspiration (ETp) of *Mrig bahar* (lit/day/tree) for 2nd year pomegranate tree at different probability levels

and 20 per cent, respectively. Minimum values of the pomegranate evapotranspiration (ETp) were observed in 30th week. These were 2.93, 2.76, 2.50 and 2.14 lit/day/tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. The total pomegranate evapotranspiration (ETp) at 70 per cent probability level over a period of 35 weeks of phenological stages in *Mrig bahar* was 112 lit/year/tree.

2nd year :

Weekly values of pomegranate evapotranspiration (ETp) for *Mrig bahar* at different probability levels are

Table 4 : Pomegranate evapotranspiration (ETp) of *Mrig bahar* (lit/day/tree) for 3rd year pomegranate tree at different probability levels								
SMW	Probability levels							
	10%	20%	30%	40%	50%	60%	70%	80%	90%
18	5.04	5.27	5.44	5.59	5.74	5.89	6.05	6.25	6.53
19	6.55	6.90	7.17	7.40	7.62	7.86	8.11	8.42	8.88
20	8.31	8.83	9.23	9.58	9.92	10.28	10.67	11.14	11.84
21	10.07	10.78	11.32	11.81	12.27	12.77	13.31	13.98	14.96
22	11.07	12.06	12.84	13.52	14.22	14.92	15.74	16.72	18.24
23	10.27	11.41	12.23	12.93	13.59	14.24	14.92	15.70	16.72
24	12.19	13.30	14.16	14.94	15.71	16.52	17.43	18.56	20.26
25	13.58	14.83	15.84	16.75	17.62	18.53	19.58	20.88	22.85
26	13.95	15.28	16.32	17.26	18.19	19.17	20.28	21.66	23.73
27	16.45	17.81	18.87	19.82	20.76	21.74	22.88	24.19	26.20
28	16.00	17.55	18.76	19.87	20.95	22.10	23.41	25.02	27.45
29	15.64	18.98	21.06	22.66	24.01	25.25	26.47	27.76	29.35
30	18.03	19.58	20.79	21.87	22.94	24.07	25.32	26.87	29.20
31	18.67	20.71	22.29	23.74	25.17	26.69	28.41	30.58	33.86
32	20.68	22.47	23.85	25.10	26.32	27.61	29.05	30.83	33.50
33	21.11	22.75	24.00	25.14	26.23	27.39	28.68	30.26	32.61
34	17.75	21.53	23.88	25.69	27.22	28.62	29.98	31.44	33.25
35	20.35	22.61	24.39	26.03	27.66	29.38	31.35	33.81	37.57
36	16.30	21.52	24.79	27.29	29.42	31.37	33.26	35.27	37.78
37	21.92	23.78	25.22	26.52	27.80	29.13	30.63	32.48	35.25
38	19.48	23.27	25.64	27.46	28.99	30.41	31.79	33.25	35.03
39	21.44	22.85	23.92	24.87	25.80	26.76	27.81	29.14	31.06
40	19.78	21.28	22.42	23.48	24.54	25.60	26.84	28.25	30.46
41	18.51	20.02	21.18	22.24	23.27	24.35	25.55	27.05	29.26
42	13.77	17.48	19.79	21.56	23.07	24.45	25.80	27.23	29.00
43	20.94	22.07	22.97	23.81	24.64	25.58	26.65	28.03	30.18
44	16.43	17.69	18.66	19.53	20.39	21.28	22.28	23.50	25.31
45	16.43	17.50	18.35	19.07	19.78	20.49	21.27	22.27	23.76
46	14.08	15.44	16.40	17.19	17.92	18.62	19.34	20.13	21.10
47	13.78	14.71	15.43	16.06	16.68	17.31	18.03	18.90	20.17
48	12.88	13.76	14.46	15.10	15.67	16.30	17.00	17.82	19.09
49	12.40	13.15	13.72	14.23	14.72	15.23	15.80	16.48	17.48
50	12.27	13.01	13.56	14.05	14.53	15.02	15.56	16.22	17.19
51	13.68	14.27	14.71	15.09	15.47	15.85	16.26	16.76	17.47
52	12.77	13.83	14.45	14.95	15.37	15.76	16.13	16.53	17.03
(l/y/tree)	532.5	588.3	628.1	662.2	694.2	726.5	761.6	803.4	863.6

presented in Table 3 for 2nd year tree. It is observed from the table that, at 70 per cent probability level weekly pomegranate evapotranspiration (ETp) ranged from 4.83 to 11.6 lit/day/tree. Maximum values of pomegranate evapotranspiration (ETp) were observed in 36th week.

These values were 12.3, 11.6, 10.3 and 7.52 lit./day/tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. Minimum values of the pomegranate evapotranspiration (ETp) are observed in 50th week. These were 5.04, 4.83, 4.51 and 4.04 lit/day/

Table 5: Pomegranate evapotranspiration (ETp) of *Mrig bahar* (lit/day/tree) for 4th year pomegranate tree at different probability levels									
SMW	Probability levels								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
18	7.00	7.32	7.56	7.77	7.97	8.18	8.41	8.68	9.07
19	9.90	10.43	10.83	11.18	11.52	11.87	12.26	12.73	13.41
20	12.77	13.57	14.18	14.72	15.24	15.78	16.38	17.12	18.19
21	15.38	16.47	17.29	18.04	18.75	19.50	20.34	21.36	22.86
22	16.46	17.93	19.10	20.10	21.14	22.19	23.40	24.86	27.12
23	14.76	16.39	17.57	18.58	19.53	20.46	21.44	22.56	24.02
24	17.14	18.70	19.91	21.01	22.10	23.24	24.51	26.11	28.49
25	18.80	20.53	21.92	23.18	24.38	25.64	27.10	28.90	31.62
26	19.46	21.32	22.77	24.08	25.38	26.75	28.29	30.21	33.10
27	22.41	24.26	25.71	27.00	28.28	29.61	31.17	32.96	35.70
28	21.94	24.08	25.74	27.26	28.75	30.32	32.11	34.33	37.66
29	21.43	26.00	28.84	31.03	32.89	34.58	36.25	38.02	40.20
30	24.70	26.83	28.48	29.97	31.43	32.97	34.69	36.82	40.00
31	25.04	27.78	29.90	31.84	33.77	35.80	38.12	41.02	45.42
32	27.60	29.99	31.83	33.49	35.13	36.85	38.77	41.15	44.70
33	28.29	30.49	32.17	33.69	35.16	36.71	38.44	40.56	43.71
34	23.79	28.84	32.00	34.42	36.47	38.34	40.17	42.12	44.54
35	27.19	30.21	32.59	34.77	36.94	39.25	41.88	45.17	50.19
36	21.76	28.73	33.10	36.44	39.28	41.88	44.41	47.09	50.45
37	29.06	31.53	33.43	35.16	36.86	38.63	40.61	43.07	46.74
38	25.82	30.86	34.00	36.40	38.44	40.32	42.15	44.09	46.44
39	28.43	30.29	31.72	32.98	34.21	35.48	36.87	38.64	41.18
40	26.84	28.88	30.44	31.88	33.31	34.75	36.43	38.35	41.34
41	25.63	27.73	29.34	30.81	32.23	33.73	35.39	37.46	40.52
42	19.22	24.39	27.62	30.09	32.20	34.12	36.01	38.00	40.47
43	29.63	31.22	32.50	33.69	34.86	36.19	37.70	39.65	42.69
44	23.64	25.46	26.86	28.11	29.34	30.62	32.05	33.82	36.41
45	23.76	25.30	26.54	27.57	28.59	29.62	30.75	32.19	34.35
46	20.50	22.46	23.86	25.02	26.08	27.09	28.14	29.29	30.71
47	20.39	21.77	22.83	23.77	24.69	25.63	26.68	27.97	29.86
48	18.92	20.23	21.25	22.19	23.02	23.96	24.98	26.19	28.06
49	18.33	19.45	20.30	21.04	21.77	22.53	23.36	24.37	25.86
50	17.79	18.85	19.65	20.36	21.05	21.76	22.55	23.51	24.91
51	19.96	20.81	21.45	22.01	22.56	23.11	23.71	24.44	25.48
52	18.21	19.73	20.61	21.32	21.92	22.47	23.01	23.58	24.29
(l/y/tree)	741.9	818.8	873.8	920.9	965.2	1009	1058	1116	1199

tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. The total pomegranate evapotranspiration (ETp) at 70 per cent probability level over a period of 35 weeks of phenological stages in *Mrig bahar* was 303 lit/year/tree.

3rd year :

Weekly values of pomegranate evapotranspiration (ETp) for *Mrig bahar* at different probability levels are presented in Table 4 for 3rd year tree. It is observed from the table that, at 70 per cent probability level weekly

Table 6 : Pomegranate evapotranspiration (ETp) of *Mrig bahar* (lit/day/tree) for 5th year pomegranate tree at different probability levels								
SMW	Probability levels							
	10%	20%	30%	40%	50%	60%	70%	80%	90%
18	8.65	9.05	9.34	9.60	9.85	10.11	10.39	10.73	11.21
19	13.29	14.00	14.54	15.01	15.47	15.95	16.46	17.09	18.01
20	17.37	18.46	19.28	20.02	20.73	21.47	22.28	23.28	24.74
21	20.86	22.33	23.45	24.46	25.43	26.45	27.58	28.97	31.01
22	22.31	24.29	25.87	27.23	28.65	30.06	31.71	33.69	36.75
23	19.43	21.58	23.14	24.47	25.71	26.94	28.24	29.70	31.62
24	22.48	24.53	26.12	27.56	28.98	30.48	32.15	34.24	37.37
25	24.23	26.46	28.25	29.88	31.42	33.05	34.93	37.24	40.75
26	24.49	26.83	28.66	30.31	31.95	33.67	35.61	38.03	41.66
27	28.22	30.56	32.38	34.01	35.62	37.29	39.25	41.51	44.96
28	26.76	29.36	31.38	33.23	35.05	36.97	39.15	41.86	45.92
29	25.82	31.33	34.76	37.40	39.64	41.68	43.69	45.82	48.45
30	29.69	32.25	34.23	36.02	37.78	39.63	41.69	44.25	48.07
31	30.83	34.21	36.82	39.21	41.58	44.09	46.93	50.51	55.93
32	34.01	36.94	39.22	41.26	43.28	45.40	47.76	50.70	55.08
33	34.81	37.51	39.58	41.45	43.27	45.17	47.30	49.91	53.78
34	29.29	35.52	39.41	42.38	44.91	47.22	49.47	51.88	54.85
35	33.51	37.23	40.17	42.86	45.54	48.38	51.62	55.67	61.86
36	26.85	35.45	40.84	44.96	48.45	51.66	54.78	58.10	62.23
37	35.89	38.93	41.28	43.42	45.51	47.69	50.15	53.18	57.71
38	31.91	38.13	42.02	44.99	47.51	49.83	52.09	54.49	57.40
39	35.16	37.47	39.23	40.79	42.31	43.89	45.61	47.79	50.94
40	32.84	35.34	37.24	39.00	40.76	42.52	44.57	46.92	50.58
41	31.58	34.16	36.15	37.96	39.71	41.56	43.61	46.16	49.93
42	23.73	30.12	34.10	37.16	39.75	42.13	44.46	46.92	49.97
43	36.65	38.62	40.20	41.67	43.12	44.77	46.64	49.05	52.81
44	29.52	31.78	33.53	35.09	36.63	38.23	40.02	42.22	45.46
45	29.70	31.63	33.17	34.46	35.74	37.03	38.44	40.24	42.94
46	25.62	28.07	29.82	31.27	32.59	33.86	35.17	36.60	38.37
47	25.83	27.58	28.92	30.11	31.27	32.47	33.80	35.43	37.83
48	24.01	25.67	26.97	28.15	29.22	30.40	31.70	33.24	35.60
49	23.31	24.73	25.80	26.75	27.68	28.64	29.71	30.99	32.88
50	22.94	24.31	25.34	26.26	27.16	28.07	29.09	30.33	32.13
51	25.58	26.68	27.50	28.21	28.91	29.62	30.39	31.32	32.67
52	24.55	26.60	27.79	28.75	29.56	30.30	31.02	31.79	32.75
(l/y/tree)	931.7	1027	1096	1155	1210	1266	1327	1399	1504

pomegranate evapotranspiration (ETp) ranged from 6.05 to 33.26 lit/day/tree. Maximum values of pomegranate evapotranspiration (ETp) were observed in 36th week. These values were 35.27, 33.26, 29.42 and 21.52 lit/day/tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. Minimum values of the pomegranate evapotranspiration (ETp) were observed in 18th week. These were 6.25, 6.05, 5.74 and 5.27 lit/day/tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. The total pomegranate evapotranspiration (ETp) at 70 per cent probability level over a period of 35 weeks of phenological stages in *Mrig bahar* was 761.6 lit/year/tree.

4th year :

Weekly values of pomegranate evapotranspiration (ETp) for *Mrig bahar* at different probability levels are presented in Table 5 for 4th year tree. It is observed from the table that, at 70 per cent probability level weekly pomegranate evapotranspiration (ETp) ranged from 8.41 to 44.41 lit/day/tree. Maximum values of pomegranate evapotranspiration (ETp) were observed in 36thweek. These values were 47.09, 44.41, 39.28 and 28.73 lit/day/tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. Minimum values of the pomegranate evapotranspiration (ETp) were observed in 18th week. These were 8.68, 8.41, 7.97 and 7.32 lit/day/tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. The total pomegranate evapotranspiration (ETp) at 70 per cent probability level over a period of 35 weeks of phenological stages in *Mrig bahar* was 1058 lit/year/tree.

5th year :

Weekly values of pomegranate evapotranspiration (ETp) for *Mrig bahar* at different probability levels are presented in Table 6 for 5th year tree. It is observed from the table that, at 70 per cent probability level weekly pomegranate evapotranspiration (ETp) ranged from 10.39 to 54.78 lit/day/tree. Maximum values of pomegranate evapotranspiration (ETp) were observed in 36th week. These values were 58.10, 54.78, 48.45 and 35.45 lit/day/tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. Minimum values of the pomegranate evapotranspiration (ETp) were observed in 18th week. These were 10.73, 10.39, 9.85 and 9.05 lit/day/

tree at probability levels 80 per cent, 70 per cent, 50 per cent and 20 per cent, respectively. The total pomegranate evapotranspiration (ETp) at 70 per cent probability level over a period of 35 weeks of phenological stages in *Mrig bahar* was 1327 lit/year/tree.

Conclusion :

The minimum and maximum values of weekly water to be applied to pomegranate tree at 70 per cent probability level for Solapur district for *Mrig bahar* were 2.76 and 4.26 lit/day/tree for 1st year, 4.83 and 11.6 1it/day/tree for 2nd year, 6.05 and 33.26 lit/day/tree for 3rd year, 8.41 to 44.41 lit/day/tree for 4th year and 10.39 to 54.78 lit/day/tree for 5th year, respectively.

The total weekly water to be applied to pomegranate tree at 70 per cent probability level for 1st to 5th year; For *Mrig bahar*: 112, 303, 761.6, 1058 and 1327 lit/year/tree, respectively.

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9th Year
★ ★ ★ ★ ★ of Excellence ★ ★ ★ ★ ★