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RESEARCH ARTICLE

PLANNING AND MANAGEMENT OF *POMEGRANATE ORCHARDS* FOR *HASTA BAHAR* (AUGUST TO MARCH)

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ABSTRACT

The study was carried out for *Hasta bahar* of pomegranate for optimum production of pomegranate for Solapur district in the semi-arid zone of Maharashtra. Generally, for crop planning, rainfall analysis and water balance studies are required to determine drought investigation, water requirement, and water surplus/ deficit. Rainfall is the major determinant of pomegranate production, especially in rain fed areas because the contribution of rain fed horticulture is almost half to the national production. The study revealed that, the greater intensity of weekly drought for *Hasta bahar* is found in Malsiras followed by Akluj and Jeyur and lowest intensity of weekly drought is found in Solapur and South Solapur for all the weeks. The water requirement at 70% probability of *Hasta bahar* is 1260.5 liters/year/tree for mature (5th year) Pomegranate tree. The percent water surplus weeks always lower than the percent water deficit weeks for all the *stations* of Solapur district for entire study period (1977-2007). The climate is semi-arid with average moisture index -56.85 percent. The uniform variation of all parameter occurred during Hasta which is helpful for healthy and disease free growth of pomegranate tree also good for pomegranate production. The most adequate beneficial and productive *season* for pomegranate production as compare other seasons.

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INTRODUCTION

Drought analysis, water requirement and water balance studies are important aspects in the rain fed farming as well as in water resource planning, irrigation scheduling, irrigation system design, moisture deficit prediction, hydrological and climatic studies, management and allocation of irrigation water. The success or failure of crops particularly under rain fed conditions is closely linked with the rainfall pattern. Drought is evaluated in a more meaningful manner by water balance approach taking into account the rainfall pattern, evapotranspiration and moisture characteristics of soil. To explain the exact level of water balance in particular area, there is need of calculation water surplus and water deficit.But in droughty area only water deficit is present.Water surplus works directly with plant engineering, environmental engineers and operations team to provide a comprehensive review of your water and chemical usage. Proper operation, monitoring and maintenance of your water treatment systems are critical for maximum return on your equipment investment. A water balance can be used to help manage water supply and predict where there may be water shortages. It is also used in irrigation and runoff assessment. Pomegranate cultivation planning in water shortage area is based on conservation, utilization and management of rainwater. Due to frequent droughts and related socio-economic constraints, per hectare yield in rainfed areas is very low (Rockstorm*et al.,* 2003). In this region, three flowering *bahars* are promoted for pomegranate production (NRCP 2009a). *Bahar* is a local word, widely used to express flowering seasons of horticulture crop, here *bahar* word is used for 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). In this study, drought investigated as meteorological drought but expressed according to pomegranate season (*bahar)*, water requirement of mature pomegranate tree at different probability levels by considering best fit probability distributions and seasonal water balance are determined to aid pomegranate growers to increase pomegranate production.

Data Collection

- The daily rainfall data of 33 years (1975–2007) collected from Indian Metrological Department, Pune.
- Meteorological data: Daily parameters (i.e. maximum temperature (T_{max},^{0}C) and minimum temperature

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(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.) also collected from Indian Meteorological Department, Pune.

Evaluation of Drought

Pomegranate *Hasta bahar*wise weekly rainfall determined for each year and weekly events were classified as drought, normal and surplus week suggested by the following criteria (Sharma *et al.,* 1979). If 'm' is the mean weekly / monthly rainfall, then a week / month receiving rainfall less than $A_1$is defined as drought, in between A_1 and A_2 is normal month and above A_2 is surplus month, where A_1 = m / 2 (50 %) and A_2 = 2 m (200%). Also if 'y' is the long term mean annual rainfall then the year is said to be classify as drought or normal or surplus as follows; Drought year: if the year's is less than or equal to y – s amount, Normal year: if the year's rainfall in between y + s and y - s amount, Surplus year: if the year's rainfall is greater than or equal to y + s amount. Where, 's' is the standard deviation of the annual rainfall series.

Probability Distribution Analysis

The Gumbel, Weibull (Maxima) and Log Normal Distributions are selected for analysis and for testing goodness of fit chi-square test is used.

Estimation of Reference Crop Evapotranspiration (ETr)

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

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

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).

Crop Coefficient (Kc)

The weekly crop coefficient values are used (Meshram, 2010).

Pomegranate Evapotranspiration (ETp)

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

ETp = ETr× kc × Crop spacing × Wetted Area × Water Application efficiency

Where,
ETp = Pomegranate evapotranspiration (mm/day)
ETr = Reference crop evapotranspiration (mm/day)
Kc = Crop coefficient of Pomegranate
Wetted area = 20% of crop spacing
Water application efficiency = 90% (drip system)

Water Balance Study

The central concept of soil water balance is shown in Figure 1 (Thornthwaite and Mather, 1955). Procedure for computation of different water balance elements is given below (Kerkides *et al*., 1996);

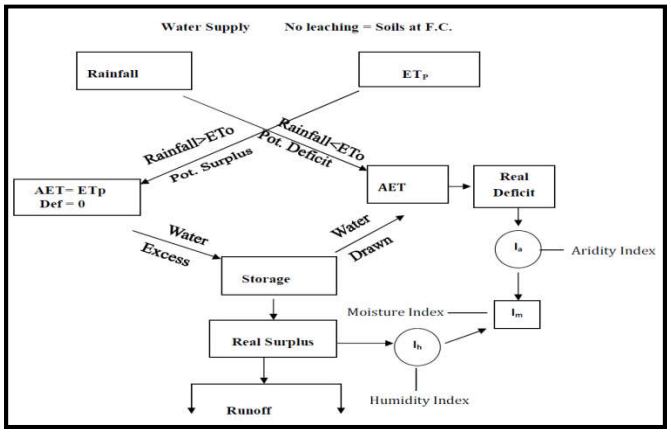

Fig. 1. Generalized flow diagram of the climatic water balance

Weekly Moisture Excess and Deficit (P-ETp)

Difference between rainfall (P) and crop evapotranspiration (ETp) gives weekly moisture excess and deficit. A negative value of this difference indicates moisture deficit, which means the amount by which the rainfall fails to supply the potential water need of area. While positive difference is moisture excess, this is the amount of excess water available for soil moisture replenishment and also for a runoff.

Water Deficit (DEF)

The amount by which the actual evapotranspiration (AET) and crop evapotranspiration differ in any week is the water deficit (DEF). Water deficit only exists when (P-ETp) is negative and is calculated by the following equation.

AET = ETp – DEF

Water Surplus (SUR)

The water surplus is the amount of positive (P-ETp) which remains in excess after recharging the soil to the field capacity by the following equation;

SUR = P – AET

Climatological Indices

On the basis of above parameters climatological indices such as humidity index (I_h), aridity index (I_a), moisture index (I_m) and moisture adequacy index (I_{ma}) were computed by using the following expressions (Thornthwaite and Mather, 1955 and 1957).

$$I_h = \frac{SUR}{ET_0} \times 100$$

$$I_a = \frac{DEF}{ET_0} \times 100$$

$$I_{ma} = \frac{AET}{ET_0} \times 100$$

$$I_m = I_h - I_a$$

Determination of Climatic Shift

The annual moisture index represents the type of prevailing climate in an area. On the basis of moisture index, following criteria has been suggested by Subramanian and Shastri (1969) to distinguish the climate:

Table 1. Moisture index critera to distinguish the climate

Moisture index, %	Type of climate
> 100	A – Per humid
80 – 100	B4 – Humid
60 – 80	B3 – Humid
40 – 60	B2 – Humid
20 – 40	B1 - Humid
0 – 20	C2 – Moist sub humid
-33.3 – 0	C1 – Dry sub humid
-66.7 - -33.3	D – Semi-arid
-100 - -66.7	E - Arid

Moisture Adequacy Index

Krishnan (1979) has suggested following criteria for weekly soil moisture adequacy index.

MAI = AE / PE x 100

Classification of MAI on Weekly basis are decided as follows

i) MAI >= 75 % -Excellent
ii) MAI = 50 to 74 % -Good (Adequate moisture)
iii) MAI = 49 to 24 %-Poor
iv) MAI < 24 % -Very Poor Moisture stress

If MAI = 0 to 49, during active growth stages of the crop, it is considered as drought. Where, AE and PE are actual and potential evapotranspiration for the period.

RESULTS AND DISCUSSION

Weekly Drought Investigation

The data of 33 years (1975-2007) were analysed, *bahar* includes 8 specific month (35 weeks of the year) and total week considers for analysis are 1155 (35week of specific bahar × 33 year). Table 1 revealed that, out of 1155 weeks the total number of drought weeks highest in Akluj is 933 weeks with 76.16 per cent and lowest in Solapur is 779 weeks with 71.80 per cent. The total normal weeks highest in north Solapur are 149 weeks with 13.73 per cent and lowest in Malsiras is 108 weeks with 9.35 per cent. Similarly the total surplus weeks highest in Madha is 181 weeks with 15.67 per cent and lowest in Akluj is 145 week with 12.55 per cent. The percent coefficient of variation between Drought, Normal and Surplus weeks for every *station*found highest in Malsiras tehsil and is 115.74 per cent and lowest in Solapur is 99.94 per cent. Also the weekly drought variation curves of *Hasta bahar* for every *station* presented in Figure 2. The results of the *bahar* wise weekly drought investigation at different stations revealed that, there is a small variation in drought, normal and surplus weeks of rainfall in the district. Similar drought analyses of rainfall have been carried out by Vladislava and Zoran (2010) forclimatological stations in Serbia; Rafiuddin *et al.* (2011) over 4 sub-regions of the Bangladesh country.

Pomegranate evapotranspiration (ETp) of *Hasta bahar* at Different Probability Level

Weekly values of Pomegranate evapotranspiration (ETp) for *Hasta bahar* at different probability levels are presented in Table 2 for 5th year tree. It is observed from the table that, at 70% probability level weekly Pomegranate evapotranspiration (ETp) ranges from 5.95 to 54.29 liters/day/tree. Maximum values of Pomegranate evapotranspiration (ETp) are observed in 14th week. These values are 56.13, 54.29, 50.84 and 43.71 liters/day/tree at probability levels 80%, 70%, 50% and 20%, respectively. Minimum values of the Pomegranate evapotranspiration (ETp) are observed in 32nd week. These are 6.32, 5.95, 5.39 and 4.60 liters/day/tree at probability levels 80%, 70%, 50% and 20%, respectively. The total Pomegranate evapotranspiration (ETp) at 70% probability level over the period of 35 weeks of phenological stages in *Hasta bahar* is 1260.5 liters/year/tree.

Weekly Water Surplus/Deficit in *Hasta bahar* for Mature (5th year) Pomegranate Tree

The number of deficit weeks highest in Akluj is 921 weeks with 84.88 per cent and lowest in Akalkot is 868 weeks with 80.00 per cent. The number of surplus weeks highest in Akalkot is 217 weeks with 20.00 per cent and lowest in Akluj and Malsiras are 164 weeks with 15.12 per cent. The weekly drought variation patterns of *Hasta bahar*mature pomegranate (5th year) for every *station*given in Table 3 and graphically presented in Figure 3.

Moisture Status under Different *Stations* of Solapur District

The concept of climatic water balance has come to be understood universally as a basis for understanding the moisture status of a place (Kerkides*et al.,* 1996). The weekly water balance elements for all the *stations* of Solapur district have been computed by Thornthwaite and Mather (1955) method. Normal weekly water balance for different *stations* under study was determined. The water balance of the different *stations* of the district has been used to study moisture status in the district (kothari et al., 2006).

Annual Moisture Status and Its Parameters of *Hasta bahar*

The elements of annual water balance for different rainfall years have been computed. The *bahar* wise water surplus and water deficit of *Hasta bahar* for complete mature Pomegranate tree (5th year) of pomegranate presented in Figure 4. Table 4 reveals, maximum and minimum value of rainfall, evapotranspiration (ET), actual evapotranspiration (AET), water deficit, water surplus, humidity index (I_h), aridity index (I_a), moisture index (I_m), moisture adequacy index (I_{ma}) during the years (1977- 2007) in all the *stations* of Solapur district for *Hasta bahar*. In all *stations* the highest maximum value of rainfall, actual evapotranspiration (AET), water deficit, water surplus, humidity index (I_h), aridity index (I_a), moisture index (I_m), moisture adequacy index (I_{ma}) are occurred in Akluj (1131), South Solapur (266.64), Karmala (1034.65), Malsiras (998.54), Malsiras (110.61), Jeyur (96.62), Malsiras (25.29), North Solapur (25.97) respectively.

Table 1. Weekly drought investigations of *Hasta bahar* for all *stations* of Solapur district

S. No.	Station	No. of Drought week	No. of Normal Week	No. of surplus Week	% of drought week	% of normal week	% of Surplus week	Coeff. of variance in %
1.	Akalkot	844	136	175	73.07	11.77	15.15	103.37
2.	Akluj	887	123	145	76.80	10.65	12.55	112.96
3.	Jeyur	933	117	175	76.16	9.55	14.29	111.50
4.	Karmala	875	120	160	75.76	10.39	13.85	110.34
5.	Madha	916	130	179	74.78	10.61	14.61	107.84
6.	Barsi	857	125	173	74.20	10.82	14.98	106.36
7.	Malsiras	899	108	148	77.84	9.35	12.81	115.74
8.	Mangalvedha	859	136	160	74.37	11.77	13.85	106.67
9.	Pandharpur	867	118	170	75.06	10.22	14.72	108.63
10.	Sangola	871	121	163	75.41	10.48	14.11	109.46
11.	Mohol	861	113	181	74.55	9.78	15.67	107.44
12.	Solapur	779	149	157	71.80	13.73	14.47	99.94
13.	S. Solapur	782	137	166	72.07	12.63	15.30	100.73
14.	N. Solapur	789	142	154	72.72	13.09	14.19	102.34

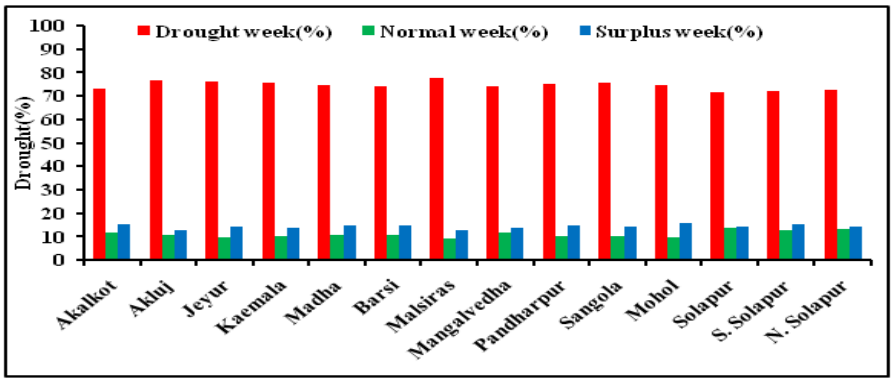

Fig. 2. Weekly drought variation curves of *Hasta bahar* for all *stations* in Solapur district

Table 2. Pomegranate evapotranspiration (ETp) of *Hasta bahar* (liters/day/tree) for 5th year (mature) pomegranate tree

M W	Probability levels								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
32	4.24	4.60	4.89	5.14	5.39	5.66	5.95	6.32	6.86
33	6.61	7.12	7.51	7.87	8.21	8.57	8.98	9.47	10.21
34	7.24	8.78	9.74	10.47	11.10	11.67	12.23	12.82	13.56
35	10.62	11.80	12.73	13.58	14.43	15.34	16.36	17.65	19.61
36	10.04	13.25	15.27	16.81	18.12	19.32	20.48	21.72	23.27
37	15.32	16.62	17.62	18.53	19.43	20.36	21.40	22.70	24.63
38	15.97	19.08	21.02	22.51	23.77	24.93	26.06	27.26	28.72
39	19.83	21.13	22.12	23.01	23.86	24.75	25.72	26.95	28.73
40	21.42	23.04	24.29	25.43	26.58	27.73	29.07	30.60	32.99
41	23.33	25.23	26.70	28.04	29.33	30.70	32.21	34.10	36.88
42	19.42	24.64	27.90	30.40	32.53	34.47	36.38	38.39	40.89
43	33.16	34.95	36.38	37.71	39.02	40.51	42.20	44.38	47.79
44	29.28	31.52	33.26	34.81	36.33	37.92	39.69	41.88	45.09
45	32.91	35.05	36.76	38.19	39.61	41.04	42.60	44.60	47.59
46	30.91	33.87	35.98	37.73	39.32	40.86	42.44	44.17	46.30
47	31.94	34.10	35.76	37.23	38.66	40.14	41.79	43.81	46.77
48	30.68	32.80	34.46	35.97	37.33	38.85	40.51	42.47	45.50
49	30.82	32.69	34.11	35.37	36.60	37.87	39.27	40.97	43.46
50	31.42	33.30	34.71	35.96	37.19	38.45	39.84	41.53	44.00
51	36.66	38.24	39.40	40.43	41.43	42.45	43.56	44.89	46.81
52	35.10	38.03	39.74	41.11	42.26	43.32	44.35	45.46	46.83
1	31.43	33.61	35.18	36.57	37.92	39.34	40.88	42.80	45.58
2	31.96	33.62	34.87	35.98	37.05	38.15	39.40	40.86	42.94
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4	32.45	34.59	36.23	37.70	39.12	40.59	42.23	44.23	47.16
5	34.79	36.63	38.02	39.24	40.42	41.63	42.98	44.62	46.97
6	35.69	37.69	39.21	40.56	41.86	43.20	44.68	46.48	49.09
7	35.24	37.57	39.29	40.78	42.21	43.68	45.26	47.15	49.85
8	35.31	38.10	40.31	42.30	44.26	46.34	48.66	51.54	55.82
9	36.83	39.93	42.32	44.50	46.62	48.84	51.34	54.43	59.02
10	38.89	41.84	43.88	45.58	47.10	48.57	50.03	51.62	53.56
11	39.95	41.96	43.47	44.81	46.09	47.42	48.87	50.63	53.17
12	36.98	41.36	44.11	46.21	48.00	49.64	51.23	52.93	55.02
13	39.47	41.76	43.49	45.01	46.47	47.96	49.59	51.53	54.23
14	38.99	43.71	46.66	48.92	50.84	52.59	54.29	56.13	58.39
(l/y/tree)	944.8	1022	1077	1124	1168	1212	1260	1317	1397

Table 3. Weekly water balance of Hasta bahar of Vth year (mature) pomegranate tree

Name of tehsil	No. of deficit week	No. of surplus week	% of deficit week	% of surplus week
Akalkot	868	217	80.00	20.00
Akluj	921	164	84.88	15.12
Jeyur	918	167	84.61	15.39
Karmala	916	169	84.42	15.58
Madha	887	198	81.75	18.25
Barsi	893	192	82.30	17.70
Malsiras	919	166	84.70	15.30
Mangalvedha	909	176	83.78	16.22
Pandharpur	884	201	81.47	18.53
Sangola	879	206	81.01	18.99
Mohol	890	195	82.03	17.97
Solapur	878	207	80.92	19.08
S. Solapur	871	214	80.28	19.72
N. Solapur	882	203	81.29	18.71

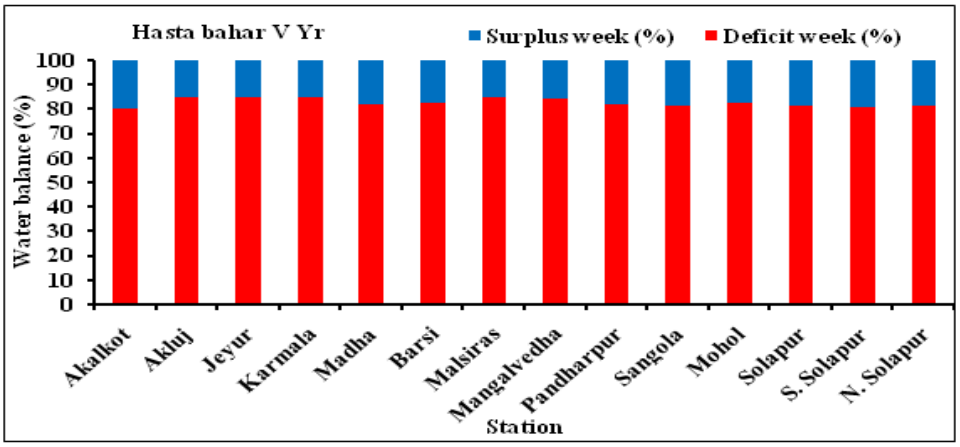

Fig. 3. Weekly water balance pattern of *Hasta bahar* for 5th year (mature) pomegranate tree

Table 4. Seasonal water balance and its different parameters of *Hasta bahar*

Station Hasta bahar	Cate-gory	Rain-fall, mm	ET,mm	AET, mm	Water Deficit, mm	Water Surplus	Humi-dity Index (I_h)	Ari-dity Index (I_a)	Moi-sture Index (I_m)	Moisture adequacy Index (I_{ma})
Akalkot	Max.	899.2	1105.7	242.8	1011.8	788.16	95.11	95.18	10.71	25.23
	Min.	125.0	812.24	47.37	652.17	53.61	5.39	74.77	-86.89	4.82
Akluj	Max.	1131.	1105.7	252.2	1014.9	998.54	110.6	95.70	25.29	24.66
	Min.	64.00	812.24	42.25	699.23	1.25	0.15	68.61	-93.48	4.30
Jeyur	Max.	775.4	1105.7	195.3	980.47	627.19	69.48	96.62	-14.10	19.90
	Min.	86.30	812.24	30.20	677.92	25.83	2.91	77.15	-90.26	3.38
Karmala	Max.	828.8	1105.7	199.9	1034.6	687.37	69.98	94.48	-14.10	21.79
	Min.	76.30	812.24	50.47	644.55	24.13	2.43	78.21	-91.39	5.52
Madha	Max.	807.0	1105.7	224.4	952.47	655.88	68.45	93.13	-9.20	24.36
	Min.	192.2	812.24	68.24	614.42	84.49	8.26	75.64	-80.43	6.87
Barsi	Max.	778.8	1105.7	204.0	1033.0	625.41	69.28	93.69	-13.73	21.04
	Min.	84.40	812.24	62.70	680.65	21.70	2.18	78.20	-91.51	6.31
Malsiras	Max.	1131	1105.7	218.0	1014.9	998.54	110.6	95.70	25.29	22.65
	Min.	64.00	812.24	42.25	690.16	21.75	2.21	77.35	-93.48	4.30
Mangal-vedha	Max.	682.1	1105.7	239.7	1003.1	475.30	57.68	94.28	-17.23	25.09
	Min.	122.2	812.24	58.85	617.30	47.40	5.35	74.91	-87.70	5.72
Pandharpur	Max.	869.1	1105.7	224.0	982.21	715.62	72.85	95.42	-12.70	24.13
	Min.	118.2	812.24	47.15	625.27	46.18	5.24	75.87	-87.97	4.58
Sangola	Max.	937.6	1105.7	247.6	987.57	714.49	69.85	93.73	-8.34	25.94
	Min.	122.6	812.24	61.57	638.34	34.93	3.52	74.06	-87.66	6.27
Mohol	Max.	880.6	1105.7	208.3	1013.0	733.21	81.22	94.90	-2.45	23.41
	Min.	134.7	812.24	50.07	631.15	36.80	4.27	76.59	-86.29	5.10
Solapur	Max.	908.8	1105.7	265.6	947.31	788.46	87.34	92.03	0.67	25.97
	Min.	158.4	812.24	82.05	623.26	76.35	7.42	68.52	-84.61	7.97
S. Solapur	Max.	893.5	1105.7	265.6	952.02	778.96	86.29	94.40	-1.02	25.97
	Min.	199.8	812.24	54.97	623.26	95.13	9.57	74.03	-80.59	5.60
N. Solapur	Max.	901.5	1105.7	265.6	952.02	765.61	84.81	93.53	-0.14	25.97
	Min.	158.4	812.24	63.57	623.26	76.00	7.42	74.03	-84.61	6.47

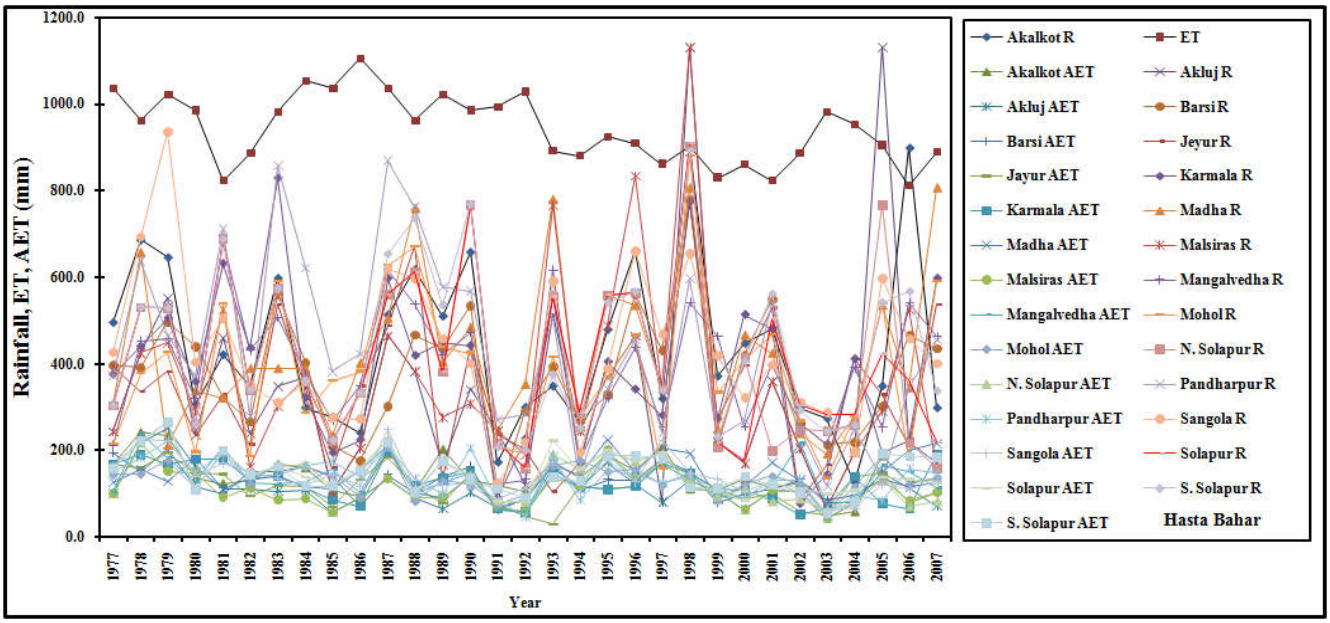

Fig.4. Seasonal water balance in different stations of Solapur district for *Hasta bahar*

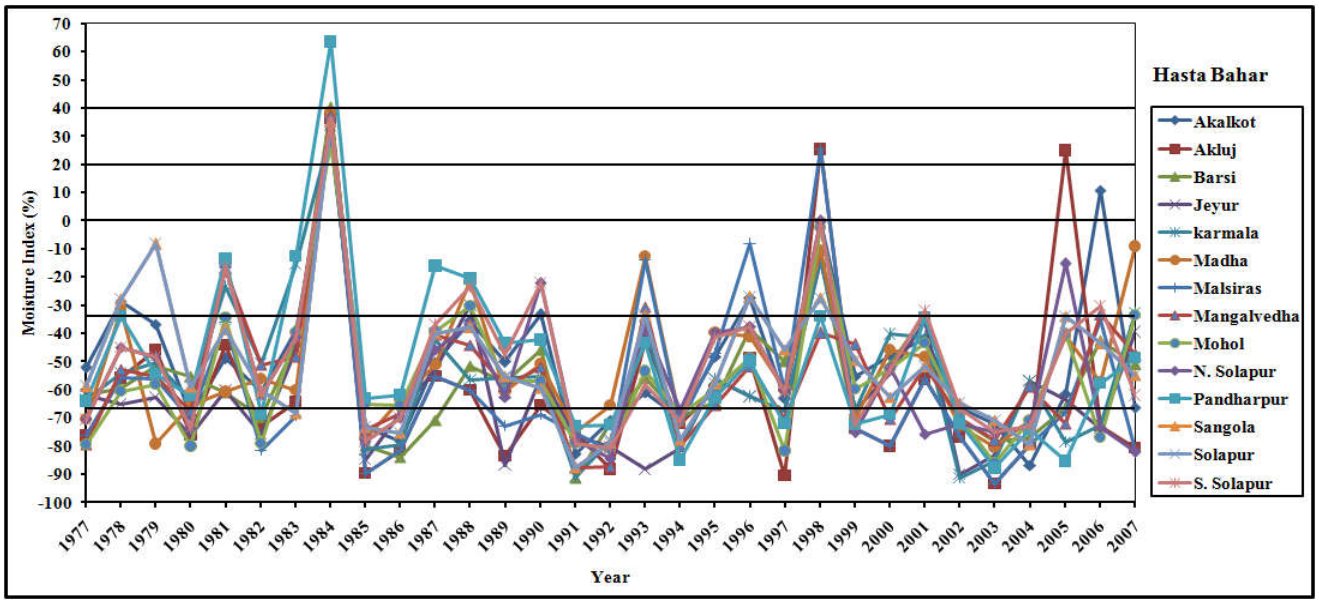

Fig. 5. Climatic shift in Hasta bahar for different rainfall stations of Solapur district

Table 5. Climatic conditions of *Hasta bahar*under different *stations*for Solapur district

Stations, Hasta bahar	Number of years of shift out of 31 years					Arid (%)	Semi-arid (%)	Dry sub-humid (%)	Moist sub-humid (%)	Humid (%)
	Arid	Semi- arid	Dry sub- humid	Moist sub- humid	Humid					
Akalkot	8	18	2	2	1	25.8	58.1	6.5	6.5	3.2
Akluj	17	11	0	0	3	54.8	35.5	0.0	0.0	9.7
Jeyur	11	17	2	0	1	35.5	54.8	6.5	0.0	3.2
Karmala	9	18	3	0	1	29.0	58.1	9.7	0.0	3.2
Madha	9	17	4	0	1	29.0	54.8	12.9	0.0	3.2
Barsi	11	18	1	0	1	35.5	58.1	3.2	0.0	3.2
Malsiras	18	9	2	0	2	58.1	29.0	6.5	0.0	6.5
Mangalvedha	10	17	3	0	1	32.3	54.8	9.7	0.0	3.2
Pandharpur	10	16	4	0	1	32.3	51.6	12.9	0.0	3.2
Sangola	7	19	4	0	1	22.6	61.3	12.9	0.0	3.2
Mohol	11	17	2	0	1	35.5	54.8	6.5	0.0	3.2
Solapur	7	19	4	0	1	22.6	61.3	12.9	0.0	3.2
S. Solapur	10	15	4	1	1	32.3	48.4	12.9	3.2	3.2
N. Solapur	13	15	1	1	1	41.9	48.4	3.2	3.2	3.2

Similarly minimum value occurred in Malsiras (64), Jeyur (30.2), Madha (614.42), Akluj (1.25), Akluj (0.15), Solapur (68.52), Akluj (-98.48), Jeyur (3.38), respectively. Above results and Figure 4 express that high water deficit prevails during month (November-March) and surplus water remains high during rainy season (August-October). It is observed that, yearly *bahar* wise water surplus always occurs before weekly water deficit in all the *stations* of Solapur district. It also indicates the heterogeneity of water surplus and deficit in different *stations* and the probability of safe crop growing year in different stations. The rainfall data of *Hasta bahar* also reveals, the weekly increase in water surplus from month August-October, thereafter it decreases slowly during November-December and then again decreases during January-March means, water deficit increases gradually.

Climatic Shift in *Hasta bahar*

The moisture index, which is the basis for climatic classification, has been studied based on pomegranate *bahar* wise change in climate. Figure 5 indicate the fluctuation of moisture index (I_m) in different years of study period. Climatic conditions in different *stations* are given in Table 5. It is observed from Table 5 that the climate at Malsiras represents high arid condition (58.1 %) fallowed by Akluj (54.8 %) and North Solapur (41.9 %) while at Solapur and Sangola it is at low arid condition (22.6 %). The data also indicate that the climatic conditions at Solapur and Sangola (61.3 %), Akluj and Karmala (58.1 %), Jeyur, Madha, Mangalvedha and Mohol (54.8 %) shifted from semi-arid to arid condition whereas climatic conditions at Madha, Sangola, Pandharpur, Solapur and South Solapur shifted to dry sub-humid by 12.9 per cent years, respectively. The climatic conditions of Akalkot, South Solapur and North Solapur shifted to moist sub-humid by 6.5, 3.2 and 3.2 per cent years, respectively. The climatic conditions at Malsiras is 6.5 % and remaining all stations of Solapur district shifted to moist sub-humid climate 3.2 per cent years. The characterization of climate is an important tool for crop planning. The study on predominant shift in climate of *Hasta bahar* of pomegranate in different *stations* reveal that five types of micro climatic conditions prevails in the district viz.; arid, having arid climate for more than 25 per cent years (>10 years); semi-arid, having semi-arid climate for more than 50 per cent years (>16 years); dry sub-humid, having dry sub-humid climate for more than 10 per cent years (>3 years); Moist sub-humid, having moist sub-humid climate for more than 0 per cent years (>0 years) and humid climate, having humid climate for 4 per cent years (>1 years). Thus, the predominant climate at Akluj and Malsiras is arid, while the climate at remaining all *stations* of Solapur district is semi-arid. The overall semi-arid climate is good for pomegranate tree and also for its fruit quality and appearance. In semi-arid climate, temperature and humidity is at moderate level which is sufficient and beneficial for pomegranate production. There are very low chances of diseases and pest problem in *Hasta bahar* of pomegranate, then no need of special provision for diseases and pest control with very low risk.

Conclusion

1. The greater intensity of weekly drought for *Hasta bahar* is found in Malsiras followed by Akluj and Jeyur and lowest intensity of weekly drought is found in Solapur and South Solapur for all the weeks. The monitoring of drought using meteorological indicators are time consuming, laborious and not on real time but using this data reliable and economical monitoring of drought is possible compared to any other improved techniques.
2. Water requirement at 70% probability of *Hasta bahar* is 1260.5 liters/year/tree for mature (5^{th} year) Pomegranate tree.
3. The percentages of water surplus weeks always lower than the percentage of water deficit weeks for all the *stations* of Solapur district for entire study period (1977-2007).
4. The climate in *Hasta bahar* is semi-arid with average moisture index -56.85 percent. Highest and lowest moisture index are observed in South Solapur (-52.11) and Jeyur (-63.27) *stations,* respectively.
5. In *Hasta bahar* uniform variation of all parameter occurred which is helpful for healthy and disease free growth of pomegranate tree also good for pomegranate production. The average climate, for *Hasta bahar*: Variate between semi-arid to arid and poor moisture adequacy index.

Hasta bahar is appropriate *bahar* for Pomegranate cultivation. The most adequate beneficial and productive *bahar* for Pomegranate is *Hasta bahar* as compare to other bahars of pomegranate. From these findings farmers and growers became aware for the actual application of water and that leads to control wastes of water and better measures to scarcity of water. This paper solves the huge problem of farmers and growers about what amount of water required according to the age of the orchards.

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