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Water excess/deficit studies at different seasons (*bahars)* of pomegranate (*Punica granatum* L.) cultivation

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ABSTRACT : The task of monitoring and controlling the field water balance is valuable for efficient management of water and soil which is required for the assessment of long term needs for supplemental irrigation, drainage and water utilization, establishment of certain soil-moisture-plant relationships and determination of optimum crop management practices.The study was carried out to estimate water surplus and deficit for 14 stations of Solapur district of Maharashtra for the period (1977-2007). The result reveals that the percentage maximum water deficit weeks was observed in Malsiras fallowed by Akluj and that of maximum surplus weeks was observed in Solapur followed by South Solapur for every pomegranate *bahar* for mature (5^{th} years) pomegranate trees.

KEY WORDS : Water excess, Water deficit, Water balance, *Bahars*

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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 is work 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, runoff assessment. The water balance can be illustrated using a water balance graph which plots levels of precipitation and evapotranspiration often on a monthly scale.

Water balance studies :

Dwindling water resources require greater efficiency in water use, both in rainfed and in irrigated agriculture. Regulated deficit irrigation provides a means of reducing water consumption under conditions of scarce water supply. Water balance conceptualized as balancing in abundance and deficit quantity of water in hydrological cycle. Whereas, water balance was first enunciated by Thornthwaite (1948) and later modified by Thornthwaite and Mather (1955). They computed water surplus, water deficit and actual evapotranspiration by utilizing the precipitation and potential evapotranspiration data (Salam and Mazrooe, 2006). This method is widely accepted because it facilitates the quantitative assessment of all major parameters of concern with water resources (Kerkides *et al*., 1996). Pomegranate trees are considered as a crop tolerant to soil water deficit (Holland *et al.*, 2009). However, very little is known about pome granatum orchard water management. Water use for this crop is for instance not listed in FAO water use book by Allen *et al.* (1998). Humic acid (polymeric polyhydroxy acid) was reported as the most significant component of organic substances in aquatic systems. Humic acid is highly benefical to both plant and soil, it is important for increasing microbial activity, it is considered as a plant growth bio-stumilant, an effective soil enhancer, it promotes nutrient uptake as chelating agent and improves vegetative characteristics, nutritional status and leaf pigments (Eissa *et al.*, 2007 and Ismail *et al.*, 2007). Humic acid are complex substances derived from ogranic matter decomposition. Humic substances have indirect effects involve improvements of soil properties such as aggregation, aeration, permeability, water

holding capacity, micronutrient transport and availabillity (Tan, 2003). Proline and other amino acids help in osmotic adjustment and crucial to sustain cellular functions under drought conditions (Farooq *et al.*, 2009). Moreover, Aseri *et al*. (2008) enhanced growth of pomegranate by using biofertilizers.

In this region, three flowering seasons (*bahars)* are promoted for pomegranate production (NRCP, 2009a). *Bahar* is a local ward used for flowering seasons of pomegranate also widely used to express flowering seasons of horticulture crop. Here *bahar* ward used to express the 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).

METHODOLOGY

The present study was carried out at 14 stations of Solapur district of Maharashtra for the period (1977-2007) :

Location of study area :

The Solapur district of Maharashtra is one of the pomegranate producing district where higher production require the best planning on the basis of draught analysis. Thus the western part of Maharashtra state, Solapur district which was selected for research work. There were 14 rainfall stations of 11 tahsils of the Solapur district, Maharashtra played key role in the research work.

Data collection :

In this study, the data required for bringing out results collected from various authenticated sources.

The daily rainfall data of 33 years (1975–2007) were collected from Indian Metrological Department, Pune.

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. collected from Indian meteorological department, Pune (1977-2007).

Crop co-efficient (Kc) :

The crop co-efficients are the properties of plants used in predicting evapotranspiration. In the published literature, week wise crop co-efficient values used for different phenological stages *i.e.* new leaf initiation, crop development, crop maturity and crop harvesting (Meshram, 2010).

Estimation of reference crop evapotranspiration (ETr) :

Reference evapotranspiration (ETr) is the rate of evapotranspiration from a hypothetical reference with assumed crop height at 0.12 m, a fixed surface resistance of 77 sec. per meter and albedo of 0.23 closely resembling the evapotranspiration from an extensive surface of green grass of uniform height, actively growing, completely shading the ground, and with adequate water (Allen *et al*., 1998). According to this definition the weekly reference crop evapotranspiration estimated by using the standard method *i.e.* Penman- Monteith (Allen *et al.,* 1998) for the present study and is given by :

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

where,

ETr = reference evapotranspiration (mm/day),

R_n = net radiation (MJ/m^2day) = (R_{ns}-R_{nl}),

R_{ns} = net short wave radiation (MJ/m^2day),

R_{nl} = net long wave radiation (MJ/m^2day),

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

G = soil heat flux ($MJm^{-2}day$),

γ = psychometric constant (kPa / ^{0}C),

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

e_a = saturation vapour pressure at temperature T (kPa),

e_d = saturation vapour pressure at dew point (kPa),

u_2 = average daily wind speed at 2 m height (m/s).

Water balance study :

The water balance is a detailed statement of the law of conservation of matter, which states that matter can neither be created nor be destroyed but can only be changed from one state or location to another. If above statement is applied to the hydrologic equations, it states that in a specified period of time, all water entering a specified area must either go into storage within its boundaries, be consumed there in, be exported there from or flow out either on the surface or underground. So, for its computation, procedure introduced by Thornthwaite and Mather (1955, 1957) was used. Thornthwaite and Mather (1955) suggested the use of potential evapotranspiration (PET) value for computation of soil water balance. Because of ambiguities in the interpretation of potential evapotranspiration, the term reference evapotranspiration (ETr) is used throughout the world (Allen *et al.,* 1998).

Weekly moisture excess and deficit (P-ETr) :

Difference between rainfall (P) and reference evapotranspiration (ETr) 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.

RESULTS AND DISCUSSION

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

Weekly *bahar* wise water balance in different stations of Solapur district :

Water balance of an area is an itemized statement of all gains, losses and changes of storage of water occurring in a given field within specified boundaries during a specified period of time considering rainfall, evapotranspiration and soil profile. Weekly rainfall and evapotranspiration data of 14 stations for mature pomegranate tree (5th year) were analyzed statistically of *Ambe*, *Mrig* and *Hasta bahar* in this section.

Weekly water balance in *Ambe bahar* for mature (5th year) pomegranate tree :

Weekly rainfall and evapotranspiration data of 14 stations analyzed statistically for the period (1977- 2007) revealed that the weekly water deficit and surplus of *Ambe bahar* mature pomegranate tree (5th year) for all stations of the Solapur district. The number of deficit weeks highest in Akluj was 1013 weeks with 93.55 per cent and lowest in South Solapur was 968 weeks with 89.68 per cent. The number of

Table 1 : Weekly water balance of *Ambhe bahar* of Vth year pomegranate tree for all tahsil of Solapur district

Sr. No.	Name of tehsil	No. of deficit week	No. of surplus week	% of deficit week	% of surplus week
1.	Akalkot	978	107	90.14	9.86
2.	Akluj	1015	70	93.55	6.45
3.	Jeyur	1012	73	93.27	6.73
4.	Karmala	1008	77	92.90	7.10
5.	Madha	1003	82	92.44	7.56
6.	Barsi	995	90	91.71	8.29
7.	Malsiras	1013	72	93.36	6.64
8.	Mangalvedha	1009	76	93.00	7.00
9.	Pandharpur	988	97	91.06	8.94
10.	Sangola	999	86	92.07	7.93
11.	Mohol	996	89	91.80	8.20
12.	Solapur	975	110	89.86	10.14
13.	S. Solapur	973	112	89.68	10.32
14.	N. Solapur	983	102	90.60	9.40

Table 2 : Weekly water balance of *Mirg bahar* of Vth year pomegranate tree for all tahsil of Solapur district

Sr. No.	Name of tehsil	No. of deficit week	No. of surplus week	% of deficit week	% of surplus week
1.	Akalkot	816	269	75.21	24.79
2.	Akluj	904	181	83.32	16.68
3.	Jeyur	892	193	82.21	17.79
4.	Karmala	870	215	80.18	19.82
5.	Madha	857	228	78.99	21.01
6.	Barsi	849	236	78.25	21.75
7.	Malsiras	885	200	81.57	18.43
8.	Mangalvedha	877	208	80.83	19.17
9.	Pandharpur	845	240	77.88	22.12
10.	Sangola	842	243	77.60	22.40
11.	Mohol	856	229	78.89	21.11
12.	Solapur	816	269	75.21	24.79
13.	S. Solapur	816	269	75.21	24.79
14.	N. Solapur	832	253	76.68	23.32

surplus weeks highest in South Solapur was 112 weeks with 10.32 per cent and lowest in Akluj was 70 weeks with 6.45 per cent. The weekly drought variation patterns of *Ambe bahar* mature pomegranate (5th year) tree for every station given in Table 1 and graphically presented in Fig. 1.

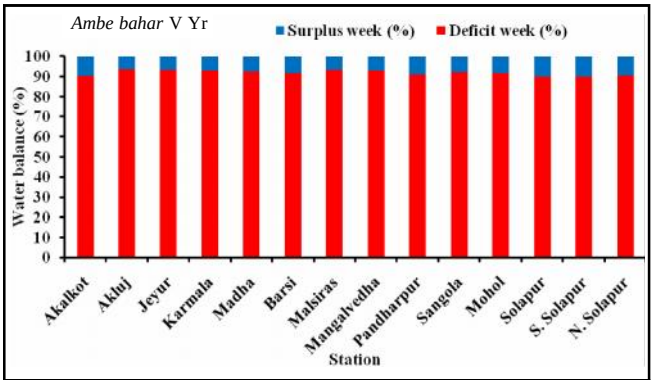

Fig. 1 : Weekly water balance pattern of *Ambe bahar* for 5th year (mature) pomegranate tree

Weekly water balance in *Mrig Bahar* of mature (5th year) pomegranate tree :

Weekly rainfall and evapotranspiration data of 14 stations analyzed statistically for the period (1977- 2007) revealed the weekly water deficit and surplus of *Mrig bahar* for all stations of the Solapur district. The number of deficit weeks highest in Akluj was 904 weeks with 83.82 per cent and lowest in Akalkot was 816 weeks with 75.21 per cent. The number of surplus weeks highest in Akalkot was 269 weeks with 24.69 per cent and lowest in Akluj was 181 weeks with 16.68 per cent. The weekly drought variation patterns of *Mrig bahar* mature pomegranate (5th year) for every station given in Table 2 and graphically presented in Fig. 2.

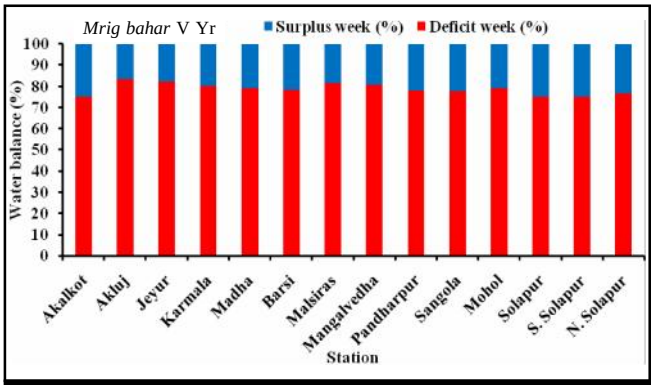

Fig. 2 : Weekly water balance pattern of *Mrig bahar* for 5th year (mature) pomegranate tree

Weekly water balance of *Hasta bahar* for mature (5th year) pomegranate tree :

Weekly rainfall and evapotranspirtion data of 14 stations analyzed statistically for the period (1977- 2007) revealed the weekly water deficit and surplus of *Hasta bahar* for all stations of the Solapur district. The number of deficit weeks highest in Akluj was 921 weeks with 84.88 per cent and lowest in Akalkot was 868 weeks with 80.00 per cent. The number of surplus weeks highest in Akalkot was 217 weeks with 20.00 per cent and lowest in Akluj and Malsiras were 164 weeks with 15.12 per cent, respectively. The weekly drought variation patterns of *Hasta bahar* mature pomegranate (5th year) for every station are given in Table 3 and graphically presented in Fig. 3. Cellier and Canejero (1998) worked on molecular and physiological responses to water deficit in drought-tolerant and drought-sensitive lines of sunflower. Kothari *et al.* (2007) worked on water balance based crop planning for Bhilwara and Singh *et al.* (2004) worked on water balance components and effect of soil moisture on yield of wheat in mid Himalayan region of

Table 3 : Weekly water balance of *Hasta bahar* of Vth year pomegranate tree for all tahsil of Solapur district

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

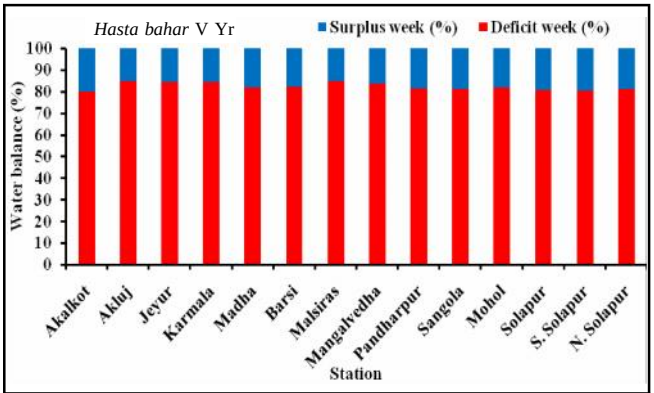

Fig. 3 : Weekly water balance pattern of *Hasta bahar* for 5th year (mature) pomegranate tree

Uttaranchal and theis results are more or less similar to the results of present study.

Conclusion :

The percentage maximum water deficit weeks was observed in Malsiras fallowed by Akluj and that of maximum surplus weeks was observed in Solapur fallowed by South Solapur for every pomegranate *bahar* for mature (5th years) pomegranate trees. The percentages of water surplus weeks was always lower than the percentage of water deficit weeks for all the stations of Solapur district for entire study period (1977-2007). From the weekly water deficit and water surplus results, it is clear that area under go arid to semi-arid region. The *Hasta bahar* of pomegranate was most suitable bahar for cultivation.

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