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Water Balance Parameters and Climatic Shift in Season June-December (Mrig Bahar) of Pomegranate (Punica granatum L.) of Solapur District, Maharashtra

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Abstract: ***The study was carried out to estimate a water balance parameters and climatic shift in Mrig bahar of Pomegranate for 14 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. The result reveals that, the climate for Mrig bahar is Variate between semi-arid to dry sub-humid. The abrupt changes, large variation from mean values of water balance parameters are occurred with poor to good moisture adequacy index.***

Keywords: Water balance, Mrig bahar, Semi-arid, Dry sub-humid, Moisture adequacy index

1. Introduction

Generally to explain the exact level of water balance in particular area, there is need of calculation water surplus and water deficit. 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 task of monitoring and controlling the field water balance is valuable for efficient management of water and soil. Such information 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.

In this region, three flowering bahars are promoted for pomegranate production (NRCP 2009a). Bahar is a local ward also widely used to express flowering seasons of horticulture crop. Here bahar ward used for flowering seasons of pomegranate. Thus, flowering seasons are defined Mrig bahar flowering period (June-July) and harvesting period (December-January).

2. Materials and Methods

Collection of Historical Rainfall Data

The daily rainfall data of 14 stations of Solapur district of 33 years (1975 – 2007) and 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 Departmen Pune. Information regarding to Pomegranate kc collected fr om PhD thesis submitted at CTAE, MPUAT, Udaipur (Meshram, 2010).

Estimation of Reference Crop Evapotranspiration (ETr)

Weekly reference evapotranspiration (ETr) values for the period (1977-2007) were computed by best method Penman-Monteith FAO-5 (Allen et al., 1998)

Pomegranate Evapotranspiration (ETp)

The weekly values of ETr and kc used to obtain weekly values of Pomegranate evapotranspiration (ETp) by equation for Mrig bahar.

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

Where,

ETp = Pomegranate evapotranspiration (mm/day),
ETr = Reference crop evapotranspiration (mm/day),
kc = Crop coefficient of Pomegranate

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).

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

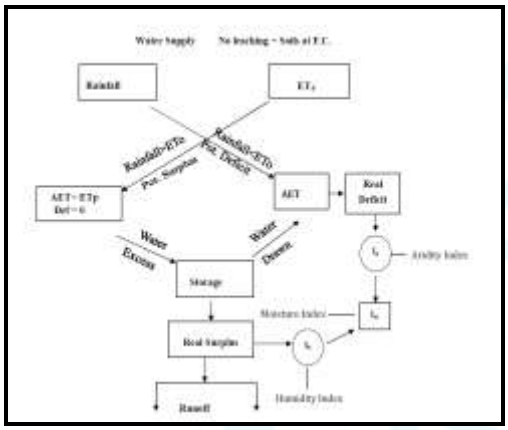

Figure 1: Generalized flow diagram of the climatic water balance

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:

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.

3. Results and Discussion

Annual Moisture Status and Its Parameters for Mrig bahar of Pomegranate under Different Stations of Solapur District

The water surplus and water deficit of Mrig bahar for complete mature pomegranate tree (5th year) of pomegranate are presented in Figure 2.

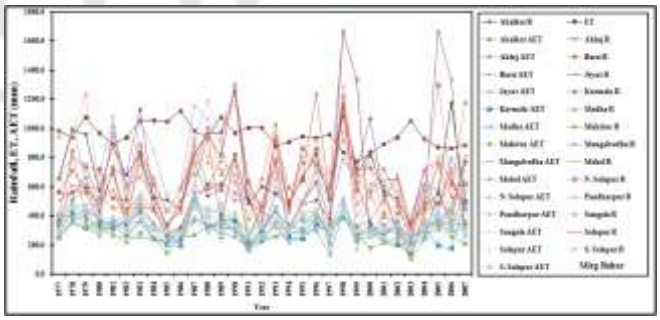

Figure 2: Seasonal water balance in Mrig bahar for different rainfall stations of Solapur district

The Table 1 revealed that, in all the stations 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 Malsiras (1667), Akluj (572.8), Malsiras (946.1), Malsiras (1251.3), Malsiras (149.6), Malsiras (89.8), Malsiras (99.3), Akluj (65.7) respectively. Similarly, minimum value occurred in Malsiras (107), Malsiras (107),

Akluj (298.5), Malsiras (0), Malsiras (0), Akluj (34.3), Akluj (-89.8), Akluj (10.2) respectively.

Above results express that high water deficit prevails during month (May –June and November - December) and surplus water remains high during rainy season (July - October). The trend of yearly water balance parameters like rainfall (PPT), pomegranate evapotranspiration (ETp) and actual evapotranspiration (AET) for different stations are shown in figures Figure 2. That also indicates the probability of safe years for crop growing in different stations of Solapur district.

Table 1: Seasonal water balance and its different parameters of Mrig bahar under different stations of Solapur district

Station Name	Cate-gory	Rain-fall, (mm)	Pomegranate ET, (mm)	AET, (mm)	Water Deficit, (mm)	Water Surplus (mm)	Humidity Index (I_H)	Aridity Index (I_A)	Moisture Index (I_M)	Moisture Adequacy Index, (I_{MA})
Akalkot	Max.	1257.0	1120.2	566.6	880.2	875.1	92.9	83.6	40.5	55.0
	Min.	342.6	773.1	172.9	417.9	131.9	14.1	45.0	-67.5	16.4
Akluj	Max.	1667.0	1120.2	572.8	946.1	1251.3	149.6	89.8	99.3	65.7
	Min.	107.0	773.1	107.0	298.5	0.0	0.0	34.3	-89.8	10.2
Jeyur	Max.	1152.7	1120.2	421.0	851.0	731.7	87.5	81.1	37.8	50.3
	Min.	266.9	773.1	185.5	415.3	53.3	5.9	49.7	-71.5	18.9
Karmala	Max.	1152.7	1120.2	490.3	925.4	731.7	88.6	85.8	37.8	55.2
	Min.	208.9	773.1	150.0	396.1	53.3	5.6	44.8	-80.2	14.2
Madha	Max.	1181.6	1120.2	559.5	828.8	669.1	79.1	82.4	41.3	63.2
	Min.	308.0	773.1	176.9	316.0	46.7	4.4	36.8	-70.8	17.6
Barsi	Max.	1085.9	1120.2	450.0	894.5	681.2	81.5	83.1	29.9	48.9
	Min.	219.4	773.1	169.9	431.5	43.1	4.1	51.1	-78.2	16.9
Malsiras	Max.	1667.0	1120.2	415.7	946.1	1251.3	149.6	89.8	99.3	49.7
	Min.	107.0	773.1	107.0	420.6	0.0	0.0	50.3	-89.8	10.2
Mangal-vedha	Max.	1013.2	1120.2	572.6	912.1	646.0	72.4	85.2	13.6	58.2
	Min.	278.8	773.1	148.5	412.0	102.5	10.4	41.8	-72.3	14.8
Pandharpur	Max.	1154.9	1120.2	536.2	839.2	738.2	82.8	79.7	22.0	54.5
	Min.	258.7	773.1	213.9	418.1	44.8	4.3	45.5	-75.4	20.3
Sangola	Max.	1233.5	1120.2	559.1	864.6	783.5	72.8	82.1	14.6	56.8
	Min.	307.8	773.1	188.5	425.5	100.5	11.1	43.2	-66.1	17.9
Mohol	Max.	1290.9	1120.2	532.9	918.2	812.2	97.1	82.9	54.4	57.2
	Min.	219.1	773.1	180.5	357.5	38.6	3.7	42.8	-79.2	17.1
Solapur	Max.	1295.8	1120.2	531.9	876.6	899.1	92.9	83.2	41.4	51.6
	Min.	300.7	773.1	176.5	407.6	109.1	11.1	48.4	-71.4	16.8
S. Solapur	Max.	1292.4	1120.2	531.9	880.0	871.2	94.9	83.6	45.7	53.0
	Min.	291.9	773.1	173.1	405.1	109.1	11.1	47.0	-72.3	16.4
N. Solapur	Max.	1295.8	1120.2	531.9	877.8	899.1	101.3	83.3	48.7	53.5
	Min.	223.0	773.1	173.2	388.9	49.8	6.4	46.5	-71.5	16.7

Climatic Shift in Mrig bahar

Climatic shift in Mrig bahar of pomegranate for different rainfall stations of Solapur district are presented in Figure 3.

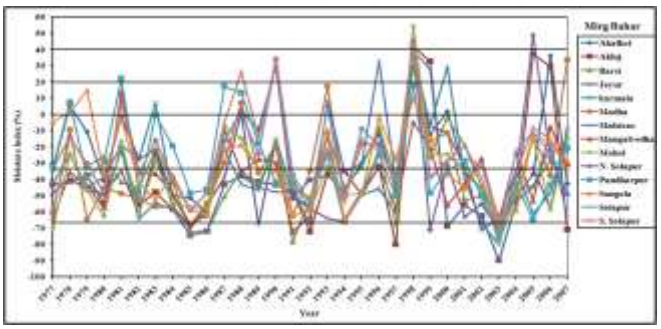

Figure 3: Climatic shift in Mrig bahar for different rainfall stations of Solapur district

Table 2 revealed that the climate at Akluj represents arid condition (22.6 %) fallowed by Karmala, Barsi and Malsiras (12.9 %) while at Akalkot, Solapur, and South Solapur it is at low arid condition (3.2 %).

The data also indicate that the climatic conditions at Malsiras (61.3 %), Akluj and Mangalvedha (58.1 %), Jeyur, Madha and Mohol (54.8 %) shifted from semi arid to arid condition whereas climatic conditions at Barsi, Solapur and South Solapur shifted to dry sub-humid 45.2, 41.9, and 38.7 per cent years respectively. The climatic conditions of Pandharpur, Akalkot, Sangola and North Solapur shifted to moist sub-humid by 16.1, 9.74, 9.73 and 9.70 per cent years respectively. The climatic conditions at Akluj (12.9 %) and Akalkot, South Solapur and North Solapur in 9.7 Per cent years shifted to moist sub-humid.

The characterization of climate is an important tool for crop planning. The study on predominant shift in climate of Mrig 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 12 per cent years (>4 years); semi arid climate, having semi-arid climate for more than 45 per cent years (>14 years); dry sub-humid climate, having dry sub-humid climate for more than 25 per cent years (>8 years); Moist sub-humid climate, having moist sub-humid climate for more than 5 per cent years (>2 years) and

humid climate , having humid climate for 6.5 per cent years (>2 years). Thus, the predominant climate at Malsiras, Mangalvedha, Madha, Jeyur and Mohol is semi arid, while the climate at Barsi and Solapur is dry sub-humid and climate for rest of the stations of Solapur district is semi-arid to dry sub-humid. The overall dry sub-humid climate is not good for pomegranate tree, fruit quality and its appearance. In dry sub-humid, temperature is low; variations in humidity are very high and uncertain excess rainfall. So there is no need of external irrigation facility to fulfill water requirement but due to high humidity and excess rainfall, large number of diseases and pest problem initiated in Mrig bahar of pomegranate. Overall to control diseases and pest is unaffordable and risky in Mrig bahar of pomegranate.

Table 2: Climatic conditions of Mrig bahar under different stations for Solapur district

Stations, Mrig 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	1	14	10	3	3	3.2	45.2	32.3	9.7	9.7
Akluj	7	18	2	0	4	22.6	58.1	6.5	0.0	12.9
Jeyur	3	17	9	1	1	9.7	54.8	29.0	3.2	3.2
Karmala	4	15	9	1	2	12.9	48.4	29.0	3.2	6.5
Madha	2	17	8	2	2	6.5	54.8	25.8	6.5	6.5
Barsi	4	12	14	0	1	12.9	38.7	45.2	0.0	3.2
Malsiras	4	19	4	1	3	12.9	61.3	12.9	3.2	9.7
Mangalvedha	2	18	10	1	0	6.5	58.1	32.3	3.2	0.0
Pandharpur	1	16	8	5	1	3.2	51.6	25.8	16.1	3.2
Sangola	1	15	12	3	0	3.2	48.4	38.7	9.7	0.0
Mohol	2	17	11	0	1	6.5	54.8	35.5	0.0	3.2
Solapur	1	12	13	3	2	3.2	38.7	41.9	9.7	6.5
S. Solapur	1	14	12	1	3	3.2	45.2	38.7	3.2	9.7
N. Solapur	2	14	9	3	3	6.5	45.2	29.0	9.7	9.7

4. Conclusions

The climate in Mirg bahar is slightly on the boundary of semi-arid to dry sub-humid and dry sub-humid to dry sub-humid with average moisture index (-33.18) per cent. Highest and lowest moisture index are observed in Akalkot (-24.72) and Jeyur (-41.45) stations respectively. The abrupt changes, large variation from mean values of water balance parameters are occurred in Mirg bahar and poor to good moisture adequacy index. Finally Mrig bahar is not a suitable bahar for beneficial production of pomegranate.

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