Eco. Env. & Cons. 28 (December Suppl. Issue) : 2022; pp. (S367-S372)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i08s.054

Analysis of water balance in relation to plant growth by use of potential evapo-transpiration and rainfall

Vishwanath[1]* and G.V. Venkataramana[2]

[1,2] ***Department of Studies in Environmental Science, University of Mysore, Mysore 570 005, Karnataka, India***

(Received 3 July, 2022; Accepted 7 September, 2022)

ABSTRACT

In order to analyze the water balance in relation to plant growth, the present study was conducted by using historical 50 years rainfall and temperature data from 1971 to 2020. The potential evapotranspiration was computed by using Thornthwaite (1948) method and the district wise water balance in relation to plant growth was calculated by using PET, 0.5 PET and rainfall. The study revealed that the highest annual PET was recorded from Raichur district (2055.4 mm) followed by Kalaburgi district (2020.6 mm) whereas the lowest PET was recorded from the Bidar district (1649.7 mm). The Koppal district has recorded the annual PET of 1848.2 mm. It is noted that the highest PET was recorded during May month and lowest during December month in all the five districts of Kalyana Karnataka. The humid period for the growth of plant was more in Bidar and Kalaburgi districts where as it was very in less in Raichur, Koppal and Ballari districts. The major part of the Kalayan Karnataka is dominated by black cotton soils. The important crops like Bt. cotton, maize, chilli, groundnut, sunflower, jowar, bajra and rabi sorghum can be successfully grown under rainfed conditions.

Key words : *Water balance, Potential evapotranspiration, Plant growth, Rainfall*

Introduction

Rainfall is crucial in agricultural planning for rainfed region which completely depends on rainfall and its distribution in any annual calendar. Variability in rainfall includes onset, distribution and cessation during the year which decides the agricultural operations. On other hands, quantum of rainfall might be same but its distribution varies according to rainfall events and crops undergo insufficient growth. The change in rainfall can't be assessed easily due process of cloud formation and raining is unpredictable, but long-term rainfall analysis could be scaled up the planning of agriculture in rainfed region. Knowledge of average monthly, seasonal and annual rainfall is helpful in understanding the general picture of the particular region. Annual rainfall varies greatly from year to year (Sridhara and Pradeep, 2021).

Some studies have documented the spatial variability of Evapotranspiration over crops in India like Kumari *et al.* (2019) estimated the water balance and length of growing period under four different types of topographical situation for efficient crop planning in Ranchi region. Saxena *et al.* (2020) investigated reference evapotranspiration trends for crop water requirement estimation in Rajasthan. Kingra *et al.* (2020) computed reference evapotranspiration, its variability and trends in different agroclimatic regions of Punjab. Aatralarasi *et al.* (2021) reported variability in reference evapotranspiration and moisture availability in three agroclimatic zones of

Punjab, India. Farooq *et al.* (2021) studied the trend of reference evapotranspiration under climate change in Himalayan region, India. Sahu *et al.* (2021) studied the quantitative assessment of spatial extent of arid and semi-arid climatic zones of India for the period from 1988 to 2018 using potential evapo-transpiration (PET) with the help of GIS.

Sattar and Khan (2017) assessed the climatic risk in terms of water availability to the crops in drought prone tract of Bihar. Ghosh *et al.* (2021) assessed the climatological risk in terms of the dry week probabilities and length of the growing period of Indian Sundarbans region for successful crop planning in Gosaba CD (Community Development) block of Indian Sundarbans.

Materials and Methods

Study area

Kalyana Karnataka is a region located in north-eastern part of Karnataka. The region comprises 6 districts namely Bidar, Kalaburagi, Yadgir, Raichur, Koppal and Ballari. The rainfall and temperature analysis was carried out for all districts of Kalyana Karnataka except Yadgir district. The districts selected for the study purpose is presented in Fig. 1

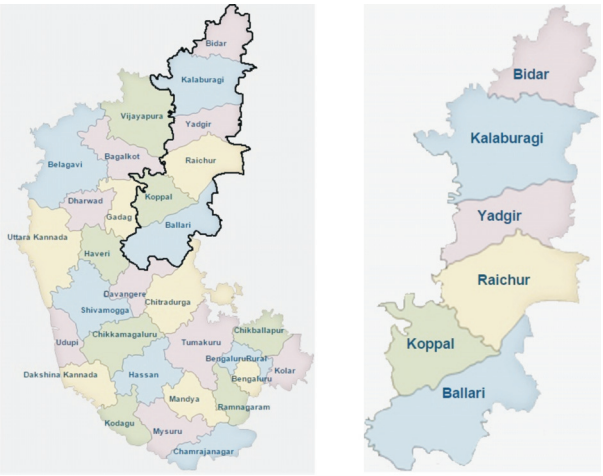

Fig. 1. Location of different districts of Kalyana Karnataka

Data used

For the proposed study, the rainfall and temperature data of 50 years (1971-2020) was collected from Karnataka State Natural Disaster Monitoring Centre (KSNDMC) Bengaluru.

Computation of potential evapotranspiration

The potential evapotranspiration was calculated by using Thornthwaite (1948) method. According to that the amount of water lost by evaporation and transpiration from a soil surface covered with vegetation is governed by climatic factors and is independent of species when moisture supply is not limiting. It is obtained by the relationship

$e = 1.6\ (10\ t/I)^a$

e = Monthly unadjusted evaporation in cm.

t = Mean monthly temperature in degree C

I = Heat index $t = \sum_1^{12} i$

i = Monthly heat index obtained by the relation

$i = (t/5)^{1.514}$

a = Coefficent which varies with heat index

$= 0.000,000,675\ I^3 - 0.0000771\ I^2 + 0.017921 + 0.49239$

The unadjusted 'e' is corrected for day length and number of days in a month. In Thornathwait's method, potential evaporation is computed by an empirical formula involving mean monthly temperature and average day-length-the values of other important factors influencing evaporation such as wind, humidity and solar radiation are considered to be linked with the variations in temperature and were therefore omitted from the formula, in order to simplify the method without affecting its usefulness. Thornthwaite's method of calculating potential evaporation was developed in a climate of summer rainfall and has not proved entirely satisfactory in other types of dry climate.

Results and Discussion

Analysis of monthly maximum and minimum temperature

The analysis of fifty years (1971-2020) monthly mean temperature among all districts of Kalyana Karnataka reveals that December is the coldest month with mean maximum temperature of 27.8^{0}C (Bidar) to 30.2^0 (Ballari) and mean minimum of 15.0^0 (Kalaburgi) to 16.7 ^{0}C (Koppal). May is the hottest month, the mean maximum temperature being 40.3 ^{0}C (Kalaburgi). The heat is oppressive till the onset of the south-west monsoon by about the first week of June. Thereafter the weather becomes slightly cooler and continues to be so till the end of the South-west monsoon season. Day temperatures show a slight increase in October. From November,

both day and night temperatures gradually decrease till December (Table 1-5).

Water balance

The potential evapotranspiration was computed by using Thornthwaite (1948) method and the district wise water balance in relation to plant growth was calculated by using PET, 0.5 PET and rainfall and the results were presented in Fig. 2 to 6. The month wise maximum and minimum temperature, rainfall and PET of all five districts of Kalyana Karnataka were presented as shown in Table 1 to 5. The study revealed that the highest annual PET was recorded from Raichur district (2055.4 mm) followed by Kalaburgi district (2020.6 mm) where as the lowest PET was recorded from the Bidar district (1649.7 mm). The Koppal district has recorded the annual PET of 1848.2 mm. The highest PET was recorded during May month and lowest during December month in all the five districts of Kalyana Karnataka. Alanka and Vennapu (2021) too reported that the spatial and temporal variability was directly related

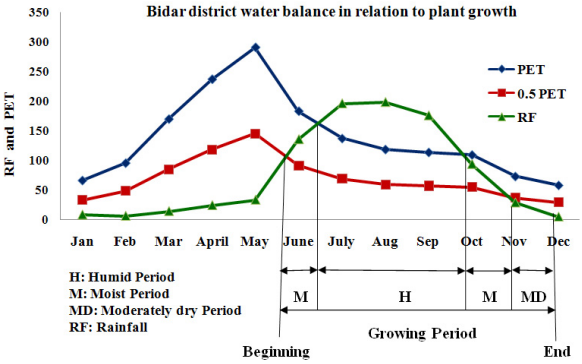

Fig. 2. Bidar district water balance in relation to plant growth

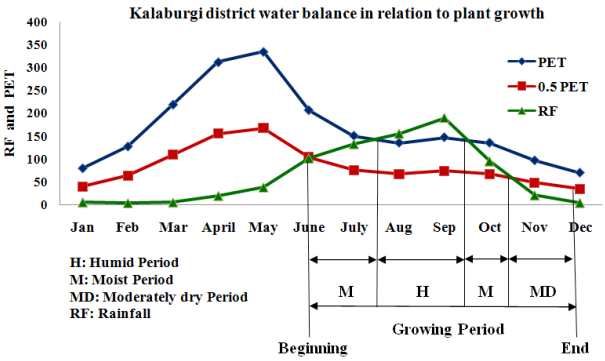

Fig. 3. Kalaburgi district water balance in relation to plant growth

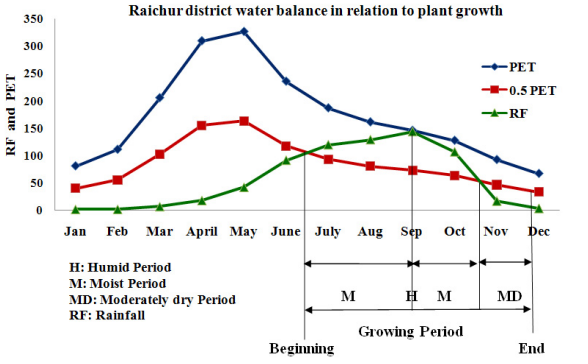

Fig. 4. Raichur district water balance in relation to plant growth

Table 1. Month wise maximum, minimum temperature, rainfall and PET of Bidar

Month	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Rainfall (mm)	PET (mm)	0.5 PET (mm)
January	28.9	16.0	8.1	66.2	33.1
February	31.9	18.3	6.2	95.4	47.7
March	35.6	21.6	14.0	169.6	84.8
April	37.8	24.4	24.0	236.7	118.4
May	38.7	25.5	33.2	290.4	145.2
June	33.5	22.9	135.5	182.9	91.5
July	29.9	21.7	196.1	136.9	68.5
August	28.6	21.2	198.3	118.3	59.2
September	29.7	21.3	175.9	113.4	56.7
October	30.1	20.4	93.6	109.1	54.6
November	28.7	17.8	28.4	72.9	36.5
December	27.8	15.6	4.6	57.9	28.9
Total			**917.8**	**1649.7**	**825.1**

to the changes in the PET. The humid period for the growth of plant was more in Bidar and Kalaburgi districts where as it was very in less Raichur, Koppal and Ballari districts. This shows that more number of crops can be grown successfully in Bidar and Kalaburgi districts under rainfed conditions.

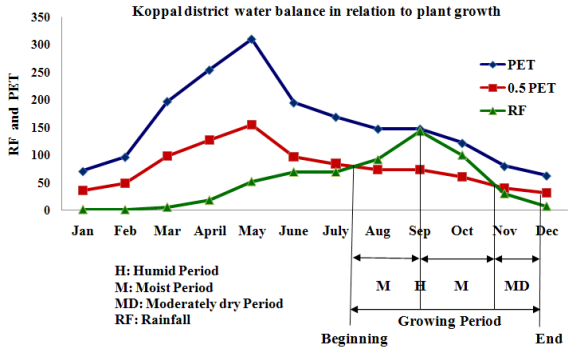

Fig. 5. Koppal district water balance in relation to plant growth

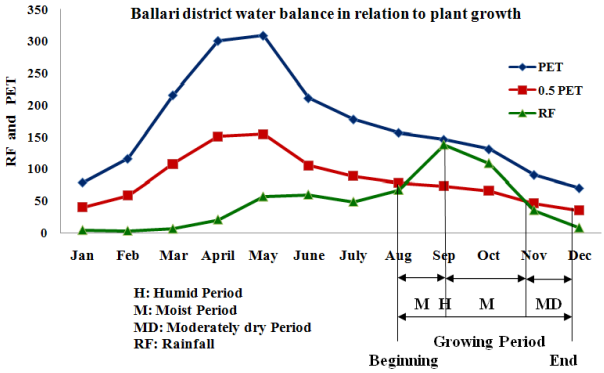

Fig. 6. Ballari district water balance in relation to plant growth

Table 2. Month wise maximum, minimum temperature, rainfall and PET of Kalaburgi

Month	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Rainfall (mm)	PET(mm)	0.5 PET (mm)
January	30.8	15.9	5.6	80.0	40.0
February	33.7	18.1	3.9	127.7	63.9
March	37.3	21.7	5.3	219.3	109.7
April	39.6	24.9	19.8	312.1	156.0
May	40.3	25.9	38.3	334.7	167.4
June	35.3	23.7	101.6	207.4	103.7
July	31.8	22.4	132.9	151.4	75.7
August	31.3	22.0	155.5	136.0	68.0
September	31.4	21.9	190.1	148.0	74.0
October	32	20.7	95.1	136.0	68.0
November	30.6	17.7	20.9	97.5	48.8
December	29.3	15.0	4.5	70.5	35.3
Total			773.5	2020.6	1010.3

Table 3. Month wise maximum, minimum temperature, rainfall and PET of Raichur

Month	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Rainfall (mm)	PET(mm)	0.5 PET (mm)
January	30.1	15.7	2.0	81.3	40.7
February	33.5	18.1	2.1	111.6	55.8
March	37.3	21.5	7.1	205.9	103.0
April	39.4	24.3	18.2	310.0	155.0
May	39.9	24.5	42.3	327.0	163.5
June	35.8	23.3	91.6	236.0	118.0
July	33.1	22.4	119.7	187.3	93.7
August	32.3	22.0	129.2	161.7	80.9
September	32.3	21.6	143.7	146.3	73.2
October	32.2	20.4	107.1	128.0	64.0
November	31.0	17.2	17.4	92.9	46.5
December	29.9	15.3	4.0	67.4	33.7
Total			684.4	2055.4	1028

Table 4. Month wise maximum, minimum temperature, rainfall and PET of Koppal

Month	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Rainfall (mm)	PET (mm)	0.5 PET (mm)
January	26.0	15.0	1.2	70.8	35.4
February	32.7	17.3	0.7	96.3	48.2
March	35.4	24.9	5.4	196.8	98.4
April	36.3	23.3	18.2	253.4	126.7
May	37.9	24.7	52.2	309.2	154.6
June	32.4	23.0	69.7	194.4	97.2
July	32.9	22.8	69.5	168.6	84.3
August	31.8	22.2	92.0	147.2	73.6
September	31.4	21.8	143.7	147.2	73.6
October	31.4	21.3	100.5	121.6	60.8
November	29.3	17.8	30.1	79.9	40.0
December	28.3	16.7	7.2	62.8	31.4
Total			590.3	1848.2	924.2

Table 5. Month wise maximum, minimum temperature, rainfall and PET of Ballari

Month	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Rainfall (mm)	PET (mm)	(mm)
January	31.4	15.8	4.2	78.9	39.5
February	34.5	18.4	3.1	116.1	58.0
March	38.1	21.5	6.3	215.7	107.9
April	40.0	24.4	20.8	300.8	150.4
May	39.2	24.8	57.2	309.0	154.5
June	34.8	23.7	60.3	211.0	105.5
July	32.3	23.3	49.0	177.8	88.9
August	31.7	22.9	67.8	156.8	78.4
September	32.1	22.2	138.2	145.9	72.9
October	31.7	21.3	109.2	130.9	65.5
November	30.6	18.6	35.8	90.8	45.4
December	30.2	15.8	7.9	69.8	34.9
Total			559.8	2003.5	1001.8

Conclusion

The results revealed that the observed PET values were higher in summer with the decrease in the monsoon season and a slight increase thereafter in the winter season. The high PET values indicated the increased water requirement for crops. Short duration crops of 90 –95 days should be preferred to be grown in rainfed uplands. Effect of water stress can be overcome with provision of suitable conservation measures, in–situ and ex–situ storage of excess runoff water in ponds and tanks for supplemental irrigation at the time of need during *kharif*. If possible, one or two tank irrigations at flowering or seed formation stage will be beneficial to the crops grown under residual soil moisture during rabi after the harvest of *kharif* crops with mulching of the crop residues over the soil surface.

Sowing of crops viz., pearl millet, sunflower, pigeon pea are recommended for the *kharif* period. Mid season correction crop like sunflower is recommended as a contingent crop under late onset of monsoon (July and early August). *Rabi* crops like winter sorghum, safflower and chickpea are recommended for this period which can be grown on residual soil moisture.

The major part of the Kalayan Karnataka is dominated by black cotton soils. The average water holding capacity of the soil is 65 % and 35 to 40 % for black and red soils respectively. The important crops like Bt. cotton, maize, chilli, groundnut, sunflower, jowar, bajra and rabi sorghum can be successfully

grown under rainfed conditions.

The in-situ moisture conservation measures like mulching, tied ridging, compartment bunds, opening of dead furrows (conservation furrows) contour cultivation, raised bed formation (ridges and furrows), small rubble check and live bunds along contour line, scooping may be followed for better moisture conservation during dry spells. The supplementary or life saving irrigation can also be planned through harvested rain water for sustainable crop production during continuous dry spells.

References

Aatralarasi, S., Kingra, P.K., Setia, R.K. and Singh, S.P. 2021. Variability in reference evapotranspiration and moisture availability in three agroclimatic zones of Punjab, India. *Journal of Agrometeorology*. 23 (2): 154-162.

Alanka, S. and Vennapu, L.R. 2021. Variability of potential evapotranspiration and moisture conditions in Srikakulam district of Andhra Pradesh. *Journal of Agrometeorology*. 23 (4): 423-427.

Farooq, Z., Kumar, R. and Singh, V.P. 2021. Trend of reference evapotranspiration under climate change in Himalayan region, India. *Journal of Agrometeorology*. *23* (1): 127-131.

Ghosh, A., Nanda, M.K., Sarkar, D., Sarkar, S., Brahmachari, K. and Ray, K. 2021. Assessing the agroclimatic potentiality in Indian Sundarbans for crop planning by analyzing rainfall time series data. *Journal of Agrometeorology.* 23 (1): 113-121.

Kingra, P.K., Aatralarasi, S., Setia, R., Kukal, S.S. and Singh, S.P. 2020. Computation of reference evapotranspiration, its variability and trends in different agroclimatic regions of Punjab. *Journal of Agrometeorology*. 22 (2) : 226-232.

Kumari, P., Balmuchu, S.A., Tirkey, D.A. and Wadood, A. 2019. Climatic water balance and length of growing period for efficient crop planning under different agrotopo-climate in Ranchi, Jharkhand. *Journal of Soil and Water Conservation*. 18(1): 59-63.

Sahu, N., Obi, R.G.P., Dash, B., Kumar, N and Singh, S.K. 2021. Assessment on spatial extent of arid and semi-arid climatic zones of India using GIS. *Journal of Agrometeorology*. 23 (2): 189-193.

Sattar, A. and Khan, S.A. 2017. Assessing climatic risk in terms of water availability to the crops in drought prone tract of Bihar. *Journal of Agrometeorology*. 19 (Special Issue - AGMET 2016) 45-50.

Saxena, R., Tiwari, A., Mathur, P. and Chakravarty, N.V.K. 2020. An investigation of reference evapotranspiration trends for crop water requirement estimation in Rajasthan. *Journal of Agrometeorology*. 22 (4): 449-456.

Sridhara, S. and Gopakkali, P. 2021. Trend and change point detection of seasonal rainfall for effective crop planning over southern transition zone of Karnataka, India. *Journal of Agrometeorology*. 23 (3): 316-323.

Thornthwaite, C.W. 1948. An approach toward a rational classification of climate. *Geographical Review*. 38 : 55-94.