The Pharma Innovation Journal 2023; SP-12(12): 1171-1175

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(12): 1171-1175

www.thepharmajournal.com
Received: 27-10-2023
Accepted: 30-11-2023

RS Talole
Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

MU Kale
Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

MS Supe
Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Corresponding Author:
RS Talole
Department of Irrigation and Drainage Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Protective irrigation planning for rainfed cropping at Akola station for climate resilient agriculture

RS Talole, MU Kale and MS Supe

Abstract
Climate change is now affecting the agriculture disastrously. The yield of crops is reducing due to erratic nature of precipitation. Protective irrigation is become inevitable for sustaining the crop productivity. In this study reference evapotranspiration, effective rainfall and crop water requirement were computed using CropWat 8.0 model. The reference evapotranspiration varies from 6.39 mm day^{-1} to 3.75 mm day^{-1}. The Cotton and Pigeon pea crop requires at least 37.3 mm/month, 120.9 mm/month, 121.4 mm/month, 114.7 mm/month, and 18.9 mm/month irrigation water during September, October, November, December and January respectively. Peak irrigation requirement of cotton and pigeon pea was found in the month of November. There is no need of protective irrigation for soybean crop due to low irrigation requirement during Kharif season. The amount of protective irrigation for Cotton and pigeon pea requires protective irrigation in the month of October (>130 mm) followed by December (>128 mm) and November (>65 mm).

Keywords: Reference evapotranspiration, effective rainfall, crop water requirement, CropWat 8.0

1. Introduction
Changing climatic conditions lead to imbalances between rainfall and crop water needs during vegetative growth, adversely affecting yields and the quality of agricultural products. The increased frequency and severity of extreme weather conditions will increase the vulnerability of the farming sector. Irrigation is a vital means by which production can be sustained in various areas. Without irrigation we risk land abandonment and severe economic hardship leading to potential relocation of agricultural production. Improved irrigation technologies and water saving practices will become essential to safeguard agricultural production in certain regions.

Management strategies are the most important way to improve agricultural water use and maintain optimal yield and production. The key is to implement management strategies that improve water use efficiency through improved irrigation scheduling and crop specific irrigation management. These strategies allow for the conservation of water and energy and decrease grower's costs. Protective irrigation, using a limited amount of water, if applied during the critical crop growth stages, can result in substantial improvement in yield and water productivity. Therefore, it's an effective response to alleviate the adverse impact of soil moisture stress during dry spells on the yield of rainfed crops.

The crop water requirements are met from the effective rainfall, irrigation water applied and the available soil moisture (Srinivasulu *et al.*, 2003 and Shengli *et al.*, 2004) [10, 7].

Considering the importance of protective irrigation in increasing crop production, a study was carried out to plan protective irrigation at Akola station using CropWat model.

2. Materials and Methods
2.1 Details of study area
Akola district is one of the eleven districts of Vidarbha Region of Maharashtra state. The district lies between 20.17 and 21.16 North latitude and 76.70 and 77.40 East longitude. Akola station is 286 m above mean sea level.

2.2 Data Collection
The daily rainfall data for seven talukas of Akola district was collected from *www.maharain.gov.in*. Maximum and minimum temperature data for Akola station was collected from All India Coordinated Research Projects on Agrometeorology, Dr. PDKV Akola for period of 22 years *i.e.*1998 to 2019.

2.3 Computation of Reference Evapotranspiration (ET_0) and Effective Rainfall

CropWat 8.0 model was used to estimate reference evapotranspiration and effective rainfall. Penman-Monteith method was used for calculating reference evapotranspiration (ETo), while USDA Soil Conservation Service method was used for calculating the effective rainfall in this study.

2.4 Computation of Crop water requirement (CWR)

The crop coefficient approach was used in CropWat model for computing the crop water requirement. The CWR module includes calculations, producing the irrigation water requirement of the crop on a decadal basis and over the total growing season, as the difference between the crop evapotranspiration under standard conditions (ETc) and the effective rainfall. Soil of Akola station is deep black soils. The total available soil moisture was taken 200.0 mm of water per meter of soil with the maximum rain infiltration rate of 20 mm day^{-1}. The maximum rooting depth for the deep black soil was taken 100 centimetres. Also, the initial soil moisture depletion (as % TAM) was taken 0 per cent.

2.5 Irrigation Scheduling

In order to develop the irrigation schedules using CropWat 8.0 model, the detailed information related to meteorological, crop and soil data was given as input to the model. In CropWat 8.0, the calculation of irrigation scheduling program is based on a soil water balance, where the soil moisture status is determined based on a daily accounting of ingoing and outgoing water in the root zone. Irrigation scheduling determines the correct measure of water to irrigate and the correct time for watering. This was done by selecting the options; irrigate at 50% critical depletion, from the irrigation-timing, refill soil to field capacity from irrigation application and irrigation efficiency 70% in scheduling criteria window. In irrigation scheduling for crops the soil moisture balance option was selected to show the status of soil moisture in the growing season.

3. Results and Discussion

3.1 Computation of reference evapotranspiration

Estimated monthly reference evapotranspiration for the duration 1998-2019 is presented in Table 1 while Fig. 1 depicts the variation of average reference evapotranspiration with average minimum and maximum temperature for Akola station.

Table 1: Average reference evapotranspiration (ETo) at Akola station district during 1998-2019

Month	Average ETo, mm day^{-1}	Month	Average ETo, mm day^{-1}
Jan	3.82	Jul	4.24
Feb	4.78	Aug	3.86
Mar	5.94	Sep	4.12
Apr	6.98	Oct	4.60
May	7.00	Nov	4.13
Jun	5.62	Dec	3.76
Average ETo		4.90	

The average monthly reference evapotranspiration varied from 3.76 mm day^{-1} to 7.00 mm day^{-1} during monsoon season. The variation in reference evapotranspiration over the year was 86.17 per cent.

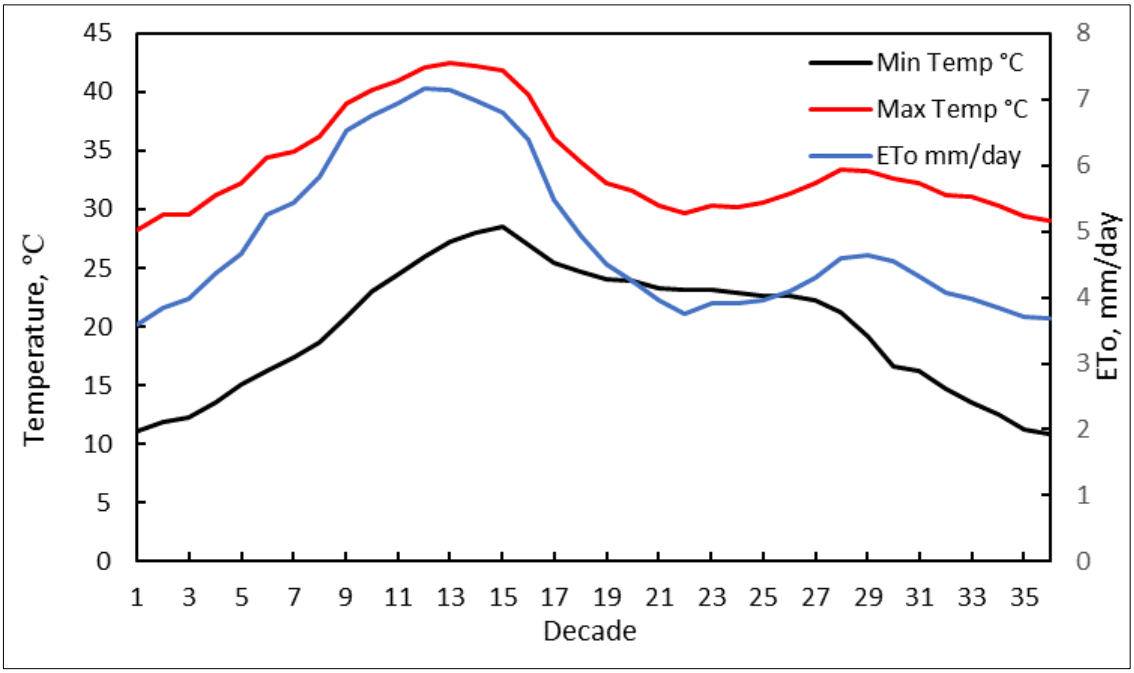

Fig 1: Average reference evapotranspiration for Akola station

Reference evapotranspiration follows the trend of maximum and minimum temperature. Reference evapotranspiration decreases during decade 17 to 27, though minimum temperature increases. This might be due to rainfall during this period.

3.2 Computation of Effective Rainfall

The decadal rainfall and corresponding effective rainfall are presented in Table. 2 while Fig 2 depicts the variation of average monthly rainfall, reference evapotranspiration and effective rainfall for Akola station.

Table 2: Monthly effective rainfall at Akola station during 1998-2019

Month	Decade	Rainfall, mm/dec	Effective rainfall, mm/dec	Month	Decade	Rainfall, mm/dec	Effective rainfall, mm/dec
Jan	1	8.5	4.2	Jul	19	108.1	44.3
	2	2.8	1.4		20	109.4	44.6
	3	4.0	2.0		21	142.0	50.8
Feb	4	3.4	1.7	Aug	22	130.3	49.5
	5	0.6	0.3		23	78.1	34.5
	6	2.2	1.1		24	96.4	40.8
Mar	7	1.8	0.9	Sept	25	89.5	38.5
	8	5.0	2.5		26	70.5	31.6
	9	3.0	1.5		27	69.9	31.4
Apr	10	0.0	0.0	Oct	28	53.6	24.8
	11	4.6	2.3		29	22.7	11.0
	12	0.0	0.0		30	7.7	3.8
May	13	0.0	0.0	Nov	31	7.3	3.6
	14	0.8	0.4		32	13.0	6.4
	15	2.2	1.1		33	0.2	0.1
Jun	16	45.9	21.5	Dec	34	0.0	0.0
	17	125.0	48.4		35	0.0	0.0
	18	97.1	41.0		36	0.6	0.3
					Total	759.9	546.3

The maximum monthly rainfall and effective rainfall is observed during the month of July, followed by August, June and September. The highest and lowest effective rainfall was found in 21 and 13 decades, respectively.

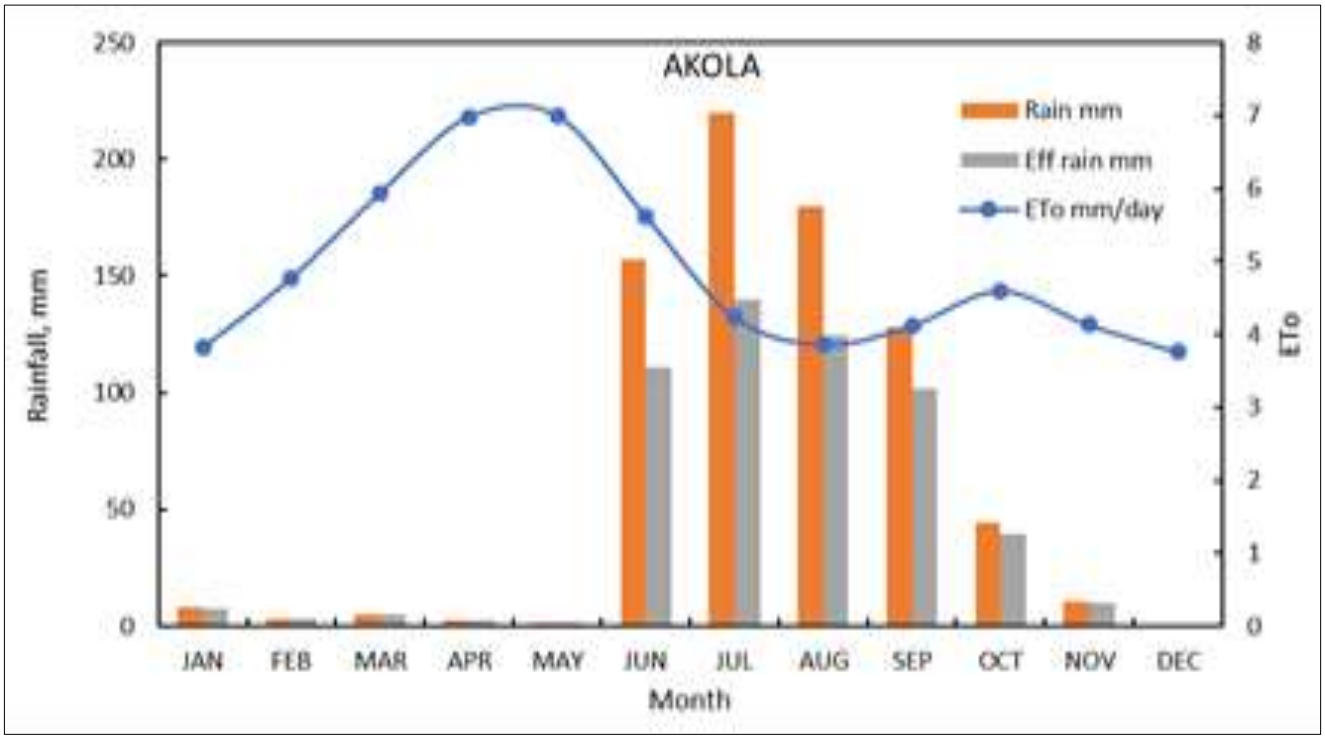

Fig 2: Average effective rainfall and reference evapotranspiration for Akola station

3.3 Protective Irrigation Planning

Considering the crop water requirement and rainfall distribution at Akola station, protective irrigation was planned. The protective irrigation was planned for major kharif crops *i.e.* cotton, pigeon pea and soybean. The protective irrigation requirement at Akola station for cotton, pigeon pea and soybean considering the growth stages, standard meteorological week and month of growing period is depicted in Fig. 3.

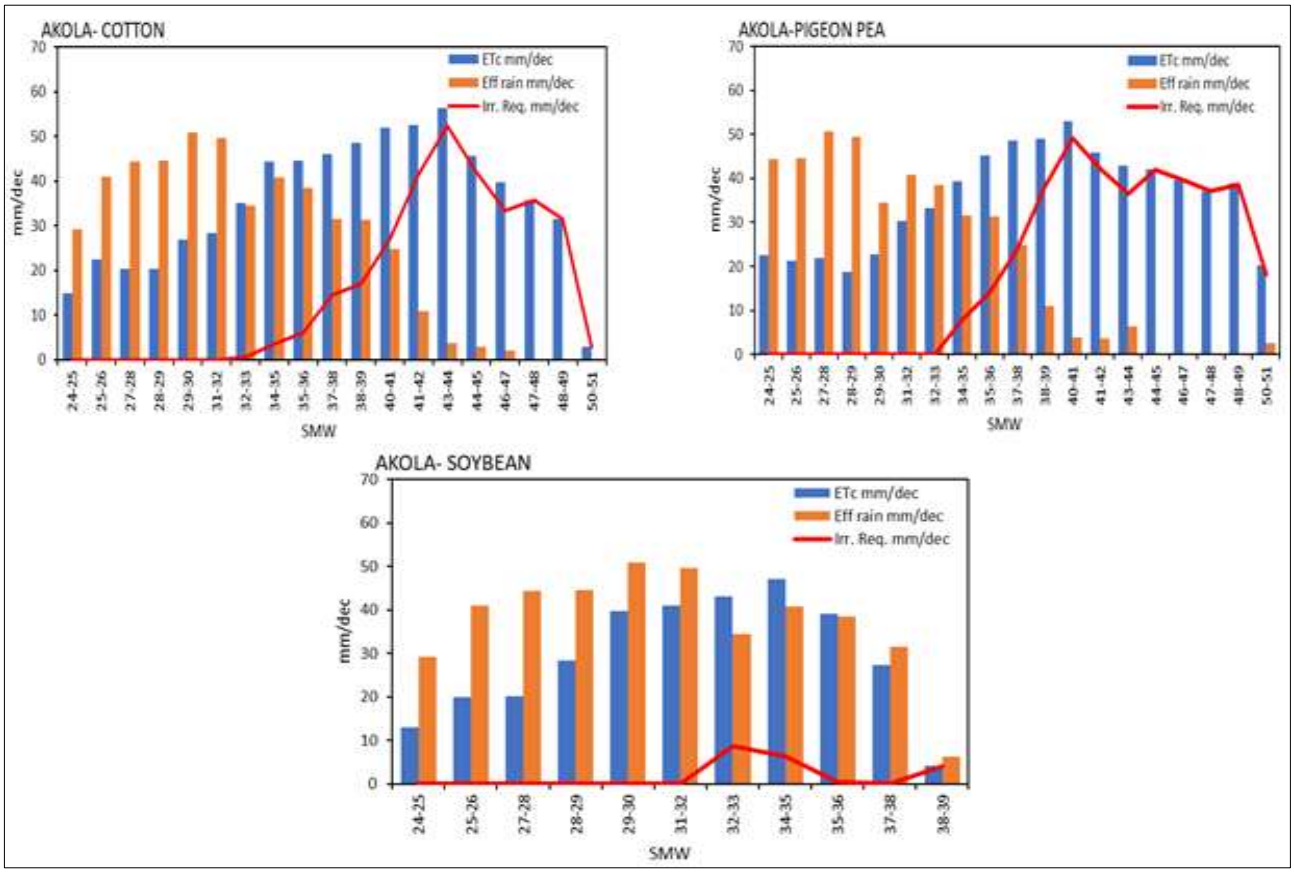

Fig 3: Irrigation water requirement for Cotton, Pigeon pea and Soybean at Akola station

The highest irrigation requirement for Cotton and Pigeon pea were found during mid-season (flowering stage) followed by late season *i.e.* in the month of October, November and December. Fig. 3 cleared that maximum protective irrigation was required for Pigeon pea followed by Cotton. In Akola district, Cotton crop requires at least 35 mm, 120 mm, 110 mm and 30 mm irrigation water during September, October, November and December, respectively whereas Pigeon pea requires 20 mm, 110 mm, 120 mm, 110 mm and 18 mm irrigation water during September, October, November, December and January respectively. The protective irrigation requirement for Soybean during was found negligible

Based on above analysis, protective irrigation requirement schedule was formulated and presented in Table 3 and Table 4.

Table 3: Protective irrigation requirement for Akola station

Month	SMW	Cotton			Pigeon pea			Soybean		
		Stage	Irr. Req.		Stage	Irr. Req.		Stage	Irr. Req.	
			mm/ dec	mm/month		mm/dec	mm/month		mm/dec	mm/month
Jun	24-25	Init	0	–	–	–	–	Init	0	0
	25-26		0						0	
Jul	27-28		0	0	Init	0	0	Dev	0	0
	28-29	Dev	0			0			0	
	29-30		0			0			0	
Aug	31-32		0	4	Dev	0	0	Mid	0	14.9
	32-33		0.5			0			8.6	
	34-35		3.5			0			6.3	
Sep	35-36	Mid	6.1	37.7		0	21.7	Late	0.4	4.5
	37-38		14.5			7.8			0	
	38-39		17.1		Mid	13.9			4.1	
Oct	40-41		27.1	120.9		23.8	111.1	–	–	–
	41-42		41.4			38.1				
	43-44	Late	52.4			49.2				
Nov	44-45		42.1	111.2		42.2	120.8			
	46-47		33.4			36.6				
	47-48		35.7		Late	42				
Dec	48-49		31.6	34.5		39.6	115.4			
	50-51		2.9			37.1				
	51-52					38.7				
Jan	01-02	–	–	0		18.1	18.1			
Total		308.3			387			19.4		

Table 4: Protective Irrigation Planning for Akola station

Month	Model Developed Protective Irrigation Schedule, mm/month			Formulated Protective Irrigation Schedule, mm/month
	Cotton	Pigeon Pea	Soybean	
Jun	0.0	-	0.0	0.0
Jul	0.0	0.0	0.0	0.0
Aug	0.0	0.0	0.0	0.0
Sep	0.0	0.0	0.0	0.0
Oct	134.7	129.9	-	134.7
Nov	0.0	65.1	-	65.1
Dec	0.0	129.4	-	129.4
Jan	-	0.0	-	0.0
Total	134.7	324.4	0.0	329.2

The irrigation requirement for Soybean crop was negligible hence there is no need of protective irrigation for soybean crop. The maximum amount of protective irrigation for Cotton was found in the month of October (>130 mm), while for pigeon pea crop it was found in the month of October (>130 mm) followed by December (>128 mm) and November (>65 mm).

The total protective irrigation water requirement at Akola station which will satisfy the water requirements of both Cotton and Pigeon pea during the growing period is estimated and presented in Table 5.

Table 5: Protective Irrigation Water Requirement of Akola station

Station	Protective Irrigation water Requirement	
	m^3/ha	litre/ha
Akola	3292	3292000

4. Conclusion

Based on precipitation patter and soil moisture balance study, it was suggested that for sustainable crop yield of major kharif crops *i.e.* cotton and pigeon pea in Akola district, the provision of protective irrigation requirement should be made through construction of water harvesting structures and same may be applied as protective irrigation during kharif season during dry spells particularly in the month of October, November and December.

5. References

1. Dastane NG. Effective rainfall in irrigated agriculture. FAO Irrigation and Drainage Paper No. 25. Rome, Italy: FAO; c1974.
2. FAO. Cropwat 8.0 for Windows user guide. Rome, Italy: FAO; c2015. Available from: www.fao.org.
3. FAO. CropWat, Land and Water. URL: http://www.fao.org/land-water/databases-and-software/cropwat/en/. 2017.
4. Oweis T, Hachum A. Improving water productivity in the dry areas of West Asia and North Africa. In: Kijne WJ, Barker R, Molden D, editors. Water productivity in agriculture: Limits and opportunities for improvement. Wallingford, UK: CABI; c2003. p. 179-197.
5. Ramakrishna R, Tata RD. Strengthening Indian Agriculture through Dryland farming: Need for reforms. Indian Journal of Agricultural Economics. 2008;63(3):460-476.
6. Rockstrom J, Wani S, Oweis T, Hatibu N. Managing water in rainfed agriculture. In: Water for Food, Water for Life: a Comprehensive Assessment of Water Management in Agriculture. London, UK: Earth Scan; c2007. p. 315-348.
7. Shengli Q. Crop water deficit estimation and irrigation scheduling in Western Jilin province, Northeast China. Agric Water Mgmt. 2004;71(1):47-60.
8. Singandhupe RB, Sethi RR. Estimation of reference evapotranspiration and crop coefficient in wheat under semi-arid environment in India. Archiv Agron Soil Sci. 2005;51(6):619-631.
9. Srinivasa R. Potential and Challenges of Rainfed Farming in India. Advances in Agronomy. 2015;113:113.
10. Srinivasulu A, Satyanarayana TV, Kumar RM, Sudha JLN. Crop water requirement in comparison to actual applied in some canal commands of Krishna Western Delta. J Agric Engg. 2003;40(4):43-50.
11. Trajkovic S, Kolokovic S. Estimating reference evapotranspiration using limited weather data. J Irrig Drain Engg. 2009;135(4):443-449.
12. Wani SP, Joshi PK, Ramakrishna YS, Sreedevi TK, Piara S, Pathak P. A new paradigm in watershed management: a must for development of rain-fed areas for inclusive growth. In: Swarup A, Bhan S, Bali JS, editors. Conservation Farming: Enhancing Productivity and Profitability of Rain-fed Areas. New Delhi, India: Soil Conservation Society of India; c2008. p. 163-178.