IJTA © Serials Publications

National Academy of Agricultural Science (NAAS) Rating : 3. 03

Study on Soil Moisture Depletion Pattern of Wheat to Different IW/CPE Irrigation Schedulings

Rajanee Salunkhe*, **M. M. Deshmukh**** **and M.U. Kale*****

ABSTRACT: *The present investigation was carried out to study on soil moisture depletion pattern of wheat to different IW/CPE irrigation schedulings. This experiment was conducted on the field of the Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the period from December to March in 2011-12 in randomized block design with five irrigation treatments and four replications. Irrigation was scheduled on the basis of climatological approach i.e. on IW/CPE ratios of 0.6, 0.8, 1.0, 1.2 and control treatment with six irrigations at critical growth stages of wheat, where the amount of irrigation water was estimated from Class-A pan evaporation data. Favorable soil moisture was maintained in the irrigation scheduling treatments of IW/CPE=1.2 (I_4) and IW/CPE=1.0 (I_3) throughout the growing period and it was always maintained in allowable depletion regime in both year. However, soil moisture was inadequate in irrigation scheduling at IW/CPE=0.6 (I_1). Highest water use efficiency was recorded in treatment I_1 in 2011-12 which may be due to lowest water use, followed by I_3 and I_4. Irrigation scheduling at IW/CPE=1.2 (I_4) recorded significantly highest grain yield 39.37 q/ha in 2011-12 as compared to rest of treatments. The results showed that the maximum yield of wheat was obtained in treatment I_3 i.e. IW/CPE=1.0 under water saving irrigation strategy with maintaining favorable soil moisture throughout growing period.*

Key words: *Soil moisture depletion pattern, IW/CPE, Water use efficiency, Crop yield.*

INTRODUCTION

As water for irrigation is a scare resource, its optimization is fundamental to water resource use. It permits better utilization of all other production factors and thus leads to increased yields per unit area and time. Water resources decrease worldwide and increases pressure due to increasing and competing demands of freshwater for drinking, agricultural, urban and industrial uses. About 75 to 80 percent of the available freshwater resource in many parts of the world is used for agriculture. Global population by 2025 will likely increase to 7.9 billion, more than 80 % of people will live in developing countries (UN, 1998). Around 36% of the 2025 world population is projected to be living in India and China alone [1]. The irrigated area should be increased by more than 20% and the irrigated crop yield should be increased by 40% by 2025 to secure the food for 8 billion people [2]. Therefore, the higher requirement of food to feed the increased population with reduced water availability for crop production forces the irrigation researchers and managers to use water-saving irrigation strategies to improve the water productivity (WP) in recent years. The main objective of irrigation is to maintain the soil moisture at optimum levels in the plant root zone, so that root will have a constant supply of moisture with adequate aeration. Efficient water management requires a thorough study of plant water relationship, climate, agronomic practices and economic assessment.

Wheat is the leading source of protein in human food, having higher protein content than either maize (corn) or rice and the other major cereals. Wheat grain is a staple food used to make flour for leavened, flat and steamed breads, biscuits, cookies, cakes, breakfast cereal, pasta, noodles, couscous and for fermentation to make beer, other alcoholic beverages or biofuel. The area, production and yield of wheat in India in year 2011-12 is 29.5 m-ha, 93.9 m-tones and 31.86 q/ha, respectively. The area, production and yield of

* Ph.D. Scholar, Deptt. of IDE, Dr. PDKV, Akola, *E-mail: rajanee.salunkhe@yahoo.com*
** Associate Professor, Deptt. of IDE, Dr. PDKV, Akola
*** Assistant Professor, Deptt. of IDE, Dr. PDKV, Akola

wheat in Maharashtra in year 2011-12 is 0.88 m-ha, 1.5 m-tones and 17.07 q/ha, respectively. However in Vidarbha, area and production of wheat is 0.23 m-ha and 0.35 m-tones respectively with yield of 15.47 q/ha, during 2011-2012. [3]. Thus productivity of wheat in Vidarbha is lower than its potential yield.

The goal of effective scheduling programs is to supply the plants with sufficient water while minimizing losses to deep percolation or runoff. Irrigation scheduling is the systematic method by which producer can decide on when to irrigate and how much water to apply. For irrigation scheduling many techniques are present, among them in climatological approach the amount of water lost by evapotranpiration is estimated from climatological data. When ET reaches in a particular level, irrigation is scheduled. The amount of irrigation given is either equal to ET or fraction of ET. Different methods of climatic approaches are IW/CPE ratio method and pan evaporation method. In IW/CPE approach, known amount of irrigation water is applied when cumulative pan evaporation reaches predetermine level [4].

Keeping these points in view experiment was conducted to assess the water need of wheat crop throughout the growing season using different levels of IW/CPE ratio, determine the irrigation interval and number of irrigations, soil moisture depletion pattern, water use efficiency and yield of wheat crop.

MATERIALS AND METHOD

Experimental site: Present investigation was laid out on the farm of Wheat Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during rabi season of 2011-12. Akola is situated at the latitude of 20^0 42' North and longitude of 77^0 02' East. Altitude of the place is 307.41 m above the mean sea level. The climate of Akola is subtropical semi-arid. The topography of the field was fairly uniform and leveled. Average annual precipitation is 750 mm and the major amount is received during the period from June to September. Winter rains are few and uncertain. The normal mean monthly maximum temperature during the hottest month (May) is 42 ^{0}C while the normal mean monthly minimum temperature in the coldest month (December) is 10.7 ^{0}C. The mean daily evaporation reaches as high as 19.0 mm in the month of May and as low as 3.00 mm in the month of August. The meteorological data during the period of experimentation was obtained from Agro-Meteorological Observatory, Dr. P.D.K.V., Akola. Physico-chemical properties of soil at experimental site were presented in Table 1.

Experimental Details: The field experiment was laid out in randomized block design, with four replications and five treatments. In four treatments out of five, irrigation was scheduled on the basis of various IW/CPE ratios [5] and in one control treatment irrigation was scheduled at critical growth stages of wheat [6]. The details of treatments are given in Table 2. Crop spacing was 18 cm row to row and plot size was 6 m×1.8 m with 20 number of plot interspaced by 2 m. Recommended fertilizer dose 80:40:40 (N:P:K) were applied by broadcasting method. Pest and disease control by chemical was carried out as per requirement. During the weeding, soil earthing up was done for the development of plant roots and breaking of crust formed during the irrigation.

Detail of Irrigation Scheduling: Water was conveyed through pipeline and measured quantity of water was applied to all sides of plot using water meter. For the purpose of irrigation scheduling the irrigation in various treatments, predetermined soil moisture constants were used. Following equations were used for irrigation scheduling. The total available water was calculated using following formulae.

$$TAW = \left[\frac{\theta_{FC} - \theta_{PWP}}{100}\right] \times \gamma \times Z_r \times 1000 \qquad (1)$$

Where,

TAW = Total available water, (mm)

θ_{FC} = Moisture content at field capacity, (%)

θ_{pwp} = Moisture content at Permanent wilting point, (%)

Table 1
Physico-chemical properties of soil at experimental site

Soil depth cm	*Sand %*	*Silt %*	*Clay %*	*Textural class*	*Bulk density gcm^{-3}*	*Soil moisture constant (%)*		*Saturated moisture content, cm^{3}cm^{-3}*	*ECdS/m*	*pH*
						FC	*PWP*			
0-60	14.8	33.7	51.5	Clay	1.18	38.25	17.21	0.40	0.77	7.78

Table 2
Treatment details

Treatment	*Specification (Irrigation at)*
I_1	IW/CPE ratio = 0.6
I_2	IW/CPE ratio = 0.8
I_3	IW/CPE ratio = 1.0
I_4	IW/CPE ratio = 1.2
I_5	Control with six irrigations at Crown Root Initiation (CRI), Maximum Tillering, Late Jointing, Flowering, Milking Stage and Dough Stage.

Table 3
Irrigation scheduling details

Sr. No.	*Particulars*		*Observation*
1	Total available water (TAW), mm		149
2	Depth of irrigation (IW), mm		75
3	Cumulative Pan	I_1 (IW/CPE=0.6)	125
	Evaporation at which	I_2 (IW/CPE=0.8)	93.8
	irrigation scheduled	I_3 (IW/CPE=1.0)	75
	treatment wise (CPE), mm	I_4 (IW/CPE=1.2)	62.5

γ = Bulk density, (gm/cm^3)

Z_r = Effective root zone depth, (m)

Using soil moisture constants, firstly total available water was determined for the experimental soil. For the purpose depth of effective root zone was taken 60 cm for wheat crop.

Depth of irrigation (IW): After determining TAW, depth of irrigation was determined considering the maximum allowable depletion of 50 percent total available water and using following equation 2.

$$IW = 0.50 \text{ X } TAW \tag{2}$$

Where,

IW- Depth of irrigation to be applied in one irrigation (mm).

Cumulative pan evaporation (CPE): For this purpose cumulative pan evaporation for respective treatments of IW/CPE ratios were determined using predetermined IW and values of ratios by using following equation 3.

$$CPE = \frac{IW}{Ratio} \tag{3}$$

Pan evaporation data were recorded daily and cumulative figures were calculated subtracting the rainfall. Total available water (TAW) was determined using soil moisture constants of the soil. Depth of irrigation water (IW) per irrigation was calculated considering 50% maximum allowable depletion. Then cumulative pan evaporation (CPE) at predetermined IW and at different IW/CPE ratios, were calculated. Accordingly irrigation scheduling details were calculated and are given in Table 3.

Irrigation Scheduling in Control Treatment: In control treatment, six irrigations were scheduled at six critical growth stages of wheat crop, viz. Crown Root Initiation (CRI), Maximum Tillering, Late Jointing, Flowering, Milking Stage and Dough Stage. In this treatment, depth of irrigation was determined by observing actual soil moisture before every irrigation and using following equation 4.

$$IWc = \left[\frac{\theta_{FC} - \theta_{BI}}{100}\right] \times \gamma \times Z_r \times 1000 \tag{4}$$

Where,

IWc = Depth of irrigation water to be applied in control treatment, (mm)

θ_{FC} = Moisture content at field capacity, (%)

θ_{BI} = Moisture content before irrigation, (%)

γ = Bulk density, (gm/cm^3)

Z_r = Effective root zone depth, (m).

Soil Moisture depletion studies: Soil moisture observations were taken by gravimetric method before and after every irrigation at various soil depths *i.e.* 15, 30 and 45cm in each treatment to observe the moisture depletion pattern [7].

Water use efficiency (WUE): Water use efficiency (WUE) was estimated by dividing the yield (Kg/ha) with the amount of water consumed by the crop (i.e. Crop evapotranspiration or crop water use, mm) during its growth period under different treatments of irrigation. Water use efficiency in different irrigation treatments was calculated by the equation 5.

$$WUE = \frac{Y}{WR} \tag{5}$$

Where,

WUE = Water use efficiency, (kg/ha-cm)

Y = Grain yield, (kg)

WR = Total water requirement, (ha-cm).

RESULTS AND DISCUSSION

Total Water Requirement of Wheat: Irrigation water is conveyed through pipe and water meter was used to apply the measured amount of water at each irrigation. Total water requirement and saving of water as influenced by different treatments was presented in Table 4. From Table 4 it was clear that

Table 4
Total water requirement of wheat

Treatment	*Number of Irrigatios*	*Irrigation water applied (mm)*	*Rainfall (mm)*	*Total water requirement (mm)*	*Saving water over control (%)*
I_1 (IW/CPE=0.6)	3	333.8	6.2	340	44
I_2 (IW/CPE=0.8)	5	483.8	6.2	490	19
I_3 (IW/CPE=1.0)	6	558.8	6.2	'565	7
I_4 (IW/CPE=1.2)	7	633.8	6.2	640	(-) 6
I_5 (Control)	6	600.2	6.2	606.4	

total water requirement of wheat was found to be highest 640 mm in 2011-12 under irrigation scheduling at IW/CPE=1.2 (I_4) even 6% more than control treatment followed by I_5 (Control) (606.4 mm), I_3 (IW/CPE=1.0) (565 mm) and I_2 (IW/CPE=0.8) (490 mm). It was found to be lowest water requirement of wheat 340 mm during 2011-12 under irrigation scheduling at IW/CPE=0.6 (I_1). Hence highest saving of water over control treatment was achieved in I_1 (44 %) at 2011-12.

Soil Moisture Depletion Pattern: It was seen from Fig 1 that soil moisture depletion before each irrigation in treatment I_1 was more than 50%, which shows the inadequacy of moisture available throughout of growing period of wheat crop. In treatment I_2 it was seen from Fig 2 that soil moisture depletions before irrigations were depleted slightly below maximum allowable depletion, which shows the inadequacy of soil moisture in later stages of crop. It shows that favourable soil moisture was not maintained throughout growing period, as it was depleted slightly below allowable depletion limit. It is seen from Fig 3 that soil moistures before irrigation in treatment I_3 were within the allowable depletion limit i.e. 50% which shows favourable soil moisture was maintained throughout the growing season of crop. It is observed from Fig. 4 that soil moisture depletions before each irrigation in treatment I_4 were always less than maximum allowable depletion that shows the adequacy of soil moisture throughout the growing season of crop [8]. Soil moisture was sufficient in treatment I_4 throughout growing period of wheat crop. It is seen from Fig 5 that, in control treatment I_5 soil moisture was depleted below maximum allowable limit i.e. 50% before three irrigations only. It may be due to that the interval of those stages of crop were more enough to deplet the soil moisture below allowable limit. In control treatment I_5, soil moisture depleted below allowable depletion before three irrigation only.

Water Use Efficiency and Yield: Highest Water Use Efficiency was recorded in treatment I_1 2011-12 reported in Table 5, which may be due to lowest water use, followed by treatments I_2, I_3, I_4 showed in figure 11. However, lowest WUE was recorded in treatment I_5 (Control). This may be due that the consumptive use in case of treatment of I_1 was lowest and whereas it was highest in case of treatment I_4. It is also seen that water use in treatment I_4 was more than treatment I_5, still water use efficiency in I_4 was more than I_5. It may be due to higher grain yield recorded in treatment I_4 as compared to treatment I_5.

Irrigation treatments significantly affected the wheat yield and Water Use Efficiency was presented in Table 5. Wheat grain yield and straw yield was obtained under treatment I_4 (IW/CPE=1.2) significantly highest and found to be superior over rest of the treatments [10] and [11] followed by treatments I_3 (IW/CPE=1.0), I_5 (Control) and I_2 IW/CPE=0.8). Treatment I_1 (IW/CPE=0.6) recorded significantly lowest yield as compared to all other treatments.

Table 5
Grain yield (q/ha) and Water Use Efficiency (q/ha-cm)

Treatments	*Grain yield (q/ha)*	*Straw yield (q/ha)*	*Consum-ptive use in (ha-cm)*	*Water use efficiency (q/ha-cm)*
I_1 (IW/CPE=0.6)	30.16	71.93	34.00	0.89
I_2 (IW/CPE=0.8)	32.83	76.20	49.00	0.67
I_3 (IW/CPE=1.0)	37.89	84.80	56.50	0.67
I_4 (IW/CPE=1.2)	39.37	88.99	64.00	0.62
I_5 – Control	35.39	81.28	60.64	0.58
Mean	35.13	80.64		
'F' test	Sig.	Sig.		
SE(m)$\pm$	0.408	0.827		
CD at 5%	1.258	2.547		
CV (%)	2.324	2.050		

CONCLUSION

Favorable soil moisture was maintained in the irrigation scheduling treatments of IW/CPE=1.2 (I_4)

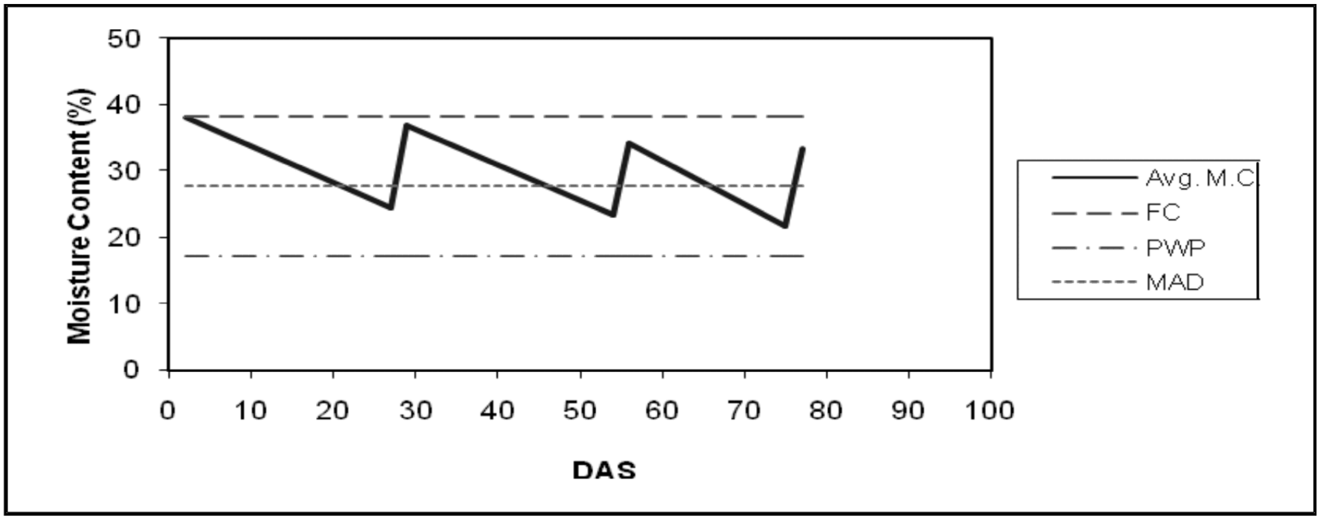

Figure 1: Soil moisture depletion pattern in 2011-12 as influenced by treatment I_1

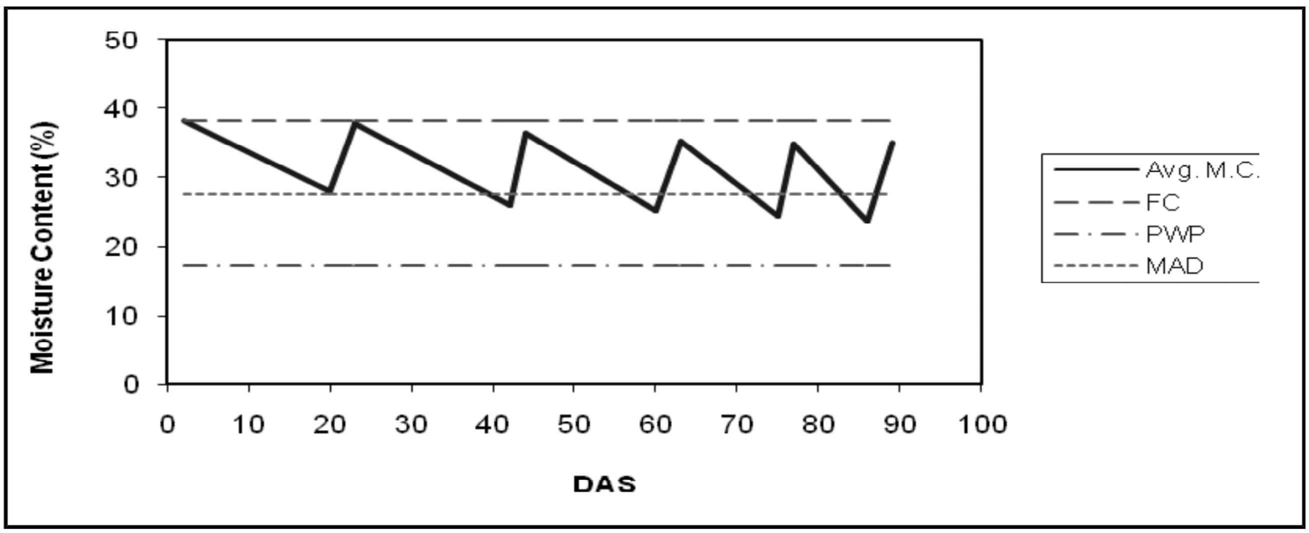

Figure 2: Soil moisture depletion pattern in 2011-12 as influenced by treatment I_2

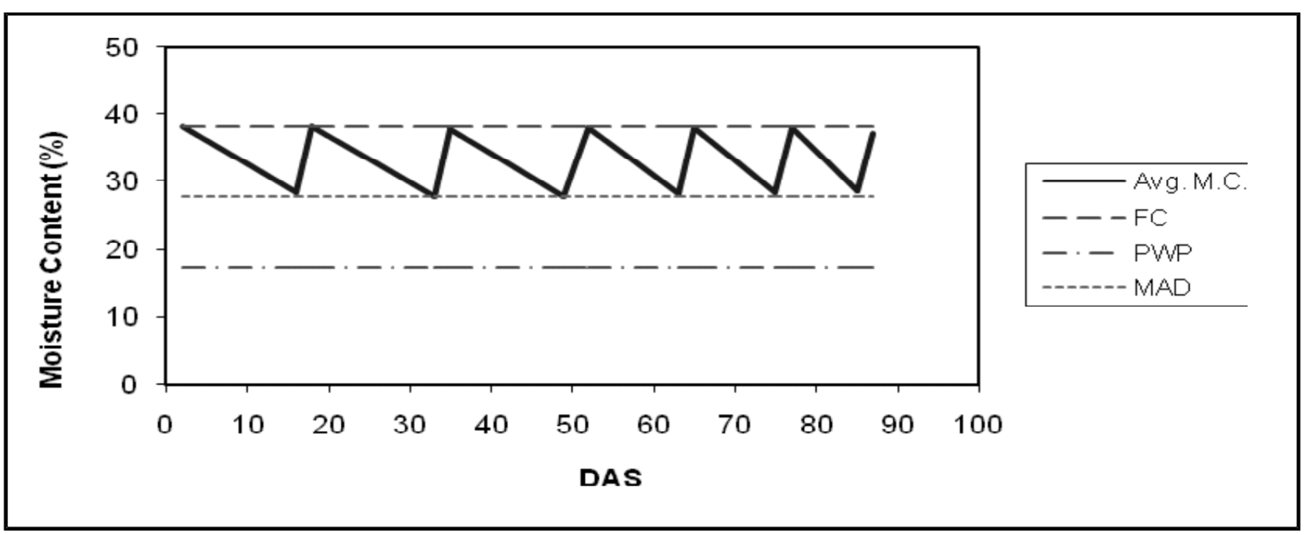

Figure 3: Soil moisture depletion pattern in 2011-12 as influenced by treatment I_3

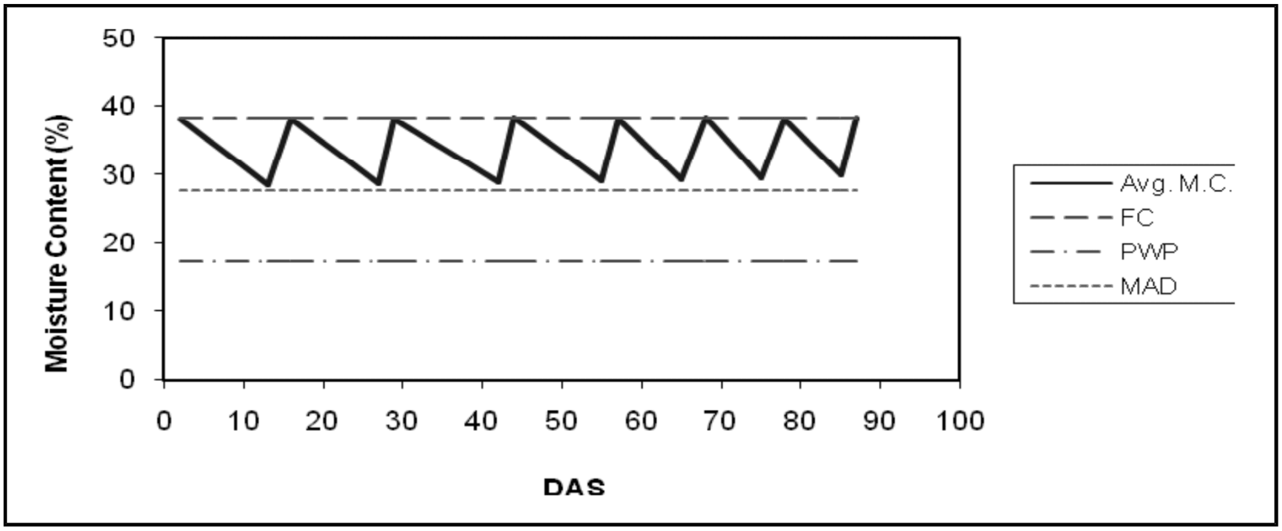

Figure 4: Soil moisture depletion pattern in 2011-12 as influenced by treatment I_4

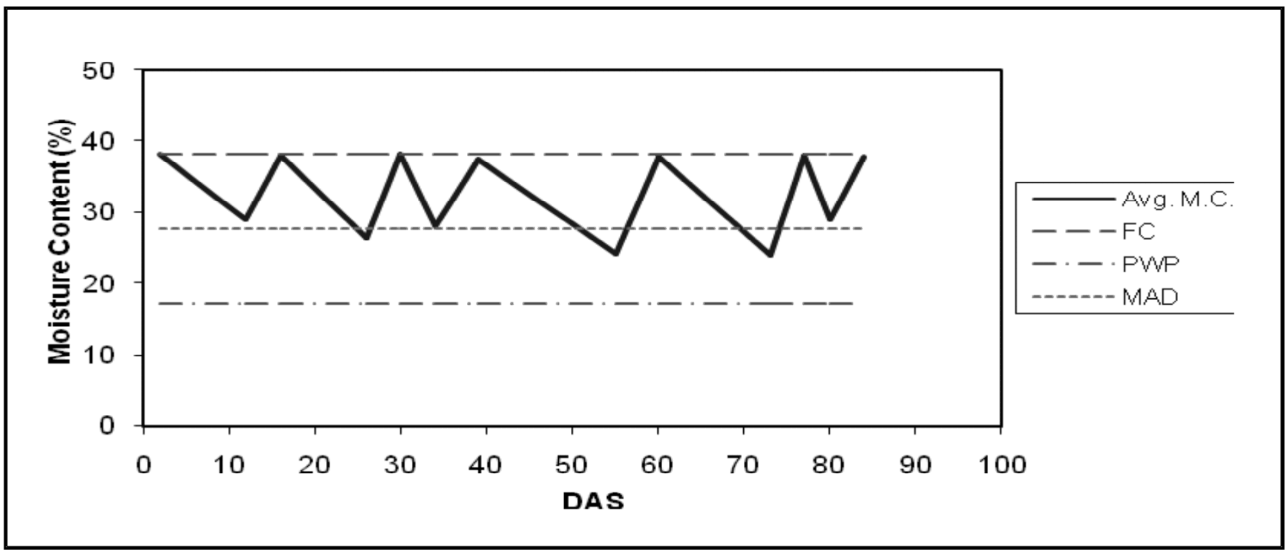

Figure 5: Soil moisture depletion pattern in 2011-12 as influenced by treatment I_5

and IW/CPE=1.0 (I_3) throughout the growing period and it was always maintained in allowable depletion regime. However, soil moisture was inadequate in irrigation scheduling at IW/CPE=0.6 (I_1). Whereas in irrigation scheduling treatments I_2 and I_5, soil moistures were slightly depleted below allowable limit. Irrigation scheduling at IW/CPE=1.0 (I_3) can save irrigation water with only marginal yield reduction compared to control irrigation treatment. Other irrigation scheduling treatments save the water, with a significant yield reduction. So that, IW/CPE=1.0 (I_3) practice can be an important and beneficial option to prevent crop yield reductions under water shortage. Irrigation scheduling at IW/CPE=1.2 (I_4) recorded significantly highest grain yield and found to be superior over rest of the treatments. Hence it may be concluded that in treatment (I_3) favorable soil moisture was maintained, and optimum WUE and yield of wheat was recorded with marginal reduction in yield and save water as compared to control treatment (I_5).

REFERENCES

Dam, J.C. and Malik R.S. (Eds.), (2003), Water productivity of irrigated crops in Sirsadistrict, India. Integration of remote sensing, crop and soil models and geographical information systems. WATPRO final report, including CD-ROM. ISBN 90-6464-864-6. 173 pp.

Lascano, R.J. and Sojka R.E., (2007), Preface. In: Irrigation of agricultural crops (Lascano, R.J., and Sojka, R.E. eds.), 2nd edition, Agronomy Monograph no. 30. ASA-CSSA-SSSA.

Anonymous (2012), Economic survey of Maharashtra (2011-2012). Govt. of Maharashtra: 83-87.

Ahlawat, I.P.S., and Gangaiah B., (2010), Response of Bt cotton (*Gossypium hirsutum*) hybrids to irrigation. Indian J. Agril. Sci. 80(4): 271-274.

Parihar, N.A. and Tiwari S.D., (2003), Effect of irrigation and nitrogen level on yield, nutrient uptake and water use of late sown wheat (Triticum aestivum). Indian J. Agron. 21(5): 132-139.

Choudhary, P.N. and Kumar V., (2004), The sensitivity of growth and yield of dwarf wheat to water stress at tree growth stages. Irrigation Sci. 1(4): 223-231.

Patel, A.G., Patel B.S. and Patel P.H. (2010), Effect of irrigation levels based on IW:CPE ratios and time of nitrogen application on yield and monetary return of frenchbean (*Phaseolus vulgaris* L.). Legume Res. 33(1):42-45.

Singh, L., Singh C.M. and Singh G. R., (2012), Response of bed planted wheat (Tritcum aestivum L.) under the different moisture regime on water use and it's efficiency. *Journal of Chemical and Pharmaceutical Research.* 4(11): 4941-4945.

Sarwar, N., Maqsood M. and Mubeen K., (2010), Effect of different levels of irrigation on yield and yield components of wheat cultivars. *Pak. J. Agri. Sci.* 47(3): 371-374.

Rathod, I.R. and Vadodaria R.P., (2010), Response of irrigation and weed management on productivity of wheat (*Triticum aestivum*) under middle Gujrat condition. Pakistan J. Biological Science.

Maheshwari, J.N., Maragatham N. and Martin G.J., (2007), Relatively simple irrigation scheduling and N application enhance the productivity of aerobic rice (Oryza sativa L.). *American J. Pl. Physiol.* 2(4): 261-268.