Int.J.Curr.Microbiol.App.Sci (2017) *6*(4): 1547-1553

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 6 Number 4 (2017) pp. 1547-1553**
Journal homepage: http://www.ijcmas.com

Original Research Article

https://doi.org/10.20546/ijcmas.2017.604.190

Agrometeorological Indices Requirement for Wheat Crop under Different Irrigation Levels

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Keywords

Wheat, Irrigation levels, GDD, HTU, PTU, PTI.

Article Info

Accepted:
15 March 2017
Available Online:
10 April 2017

A B S T R A C T

The field experiment was conducted at Agronomy Farm, Anand Agricultural University, Anand (Lat.: 22^{0}35' N, Log.: 72^{0}55' E & 45.1 m above msl) during *rabi* season in 2011-2012. The treatment comprised of five levels of irrigation schedule *Viz*., I_1 (CRI, TL, BT, FL, ML, SD), I_2 (0.4 IW: CPE ratio), I_3 (0.6 IW: CPE ratio), I_4 (0.8 IW: CPE ratio) and I_5 (1.0 IW: CPE ratio) in randomized block design (RBD) within four replications. The main aim is to quantify the agrometeorological indices of wheat crop. The different agrometeorological indices were evaluated i.e. growing degree Days (GDD), Heliothermal Unit (HTU), Photothermal Unit (PTU) and Relative temperature Disparity (RTD). The results revealed that the different irrigation level was found alter the agrometeorological indices and its efficiency at different phenophases of wheat crop. The higher GDD (3532^{0}C day), HTU (32759 ^{0}C day), and PTU (38652 ^{0}C day) were found with I_1 (CRI, TL, BT, FL, ML, SD) irrigation level. The relative temperature disparity (RTD) was found higher under I3 (0.6 IW: CPE ratio) irrigation level and photothermal index (PTI) was found varying as fluctuating trend among all irrigation levels.

Introduction

Agrometeorological indices requirement of wheat crop was varies in different irrigation application and weather conditions. Wheat (*Triticum aestivum L.*) is one of the most important cereal crops globally. India covers about 30.2 million hectares area with total production of 93.5 million tonnes and productivity of 30.9 q/ha (Anonymous, 2016). Gujarat ranks sixth in wheat production in country and area, production and productivity, averaged are 0.85 million ha, 2.4 tonnes and 2.9 tonnes ha^{-1}, respectively (Anonymous, 2016). The minimum growth temperature for is 3-4 °C, the optimum temperature about 25 °C, and the maximum from about 30-32 °C.

The day and night temperature played vital role to completion the primary requirement of degree day. The minimum temperature quite high value was promoted the higher respiration and ultimately increases the water requirement and lowers the assimilation rate. Changes in climatic variables like rise in temperature and decline in rainfall may be more frequent in future as suggested by the Intergovernmental Panel on Climate Change

(IPCC, 2007). Pre anthesis and post- anthesis high temperature and heat may have huge impacts upon wheat growth, and stress reduced the photosynthetic efficiency of crop (Wang *et al.*, 2011). You *et al.*, (2009) observed significant reduction in economical yield due to rise in temperature and concluded that a 1.8°C rise in temperature caused 3-10% reduction in wheat yields. Winter crops are vulnerable to high temperature during reproductive stages especially night temperature (Tmin) and differential response of temperature change (rise) to various crops has been noticed under different production environments (Kalra, 2008). Crop is exposed to a variety of weather conditions during its different phenophases of growth, resulting in large variations in growth rate and yield. For quantifying the thermal relation of crops, thermal units approach is widely used (Ramteke *et al.*, 1996) and has been further modified to include photothermal units and heliothermal units (Rao *et al.*, 1999). Water is essential at every developmental phase of crop growth starting from seed germination to crop maturity for harvesting the maximum potential yield of wheat. There is a positive correlation between grain yield and irrigation frequencies at the critical phases Irrigation missing at some critical growth stage sometime drastically reduces grain yield (Chauhan *et al.*, 2008) due to not proper drought stage attained and resulted were found to lower test weight. Similarly, over irrigation also sometimes tends to decrease grain yield instead of increasing yield (Kahlown and Azam, 2002).

Materials and Methods

The field experiment was conducted at Agronomy Farm, Anand Agricultural University, (AAU), Anand, Gujarat (Lat.: $22^0$35' N, Log.: $72^0$55' E and 45.1 m above msl) during *rabi* season in 2011-2012. The treatment comprised of five levels of irrigation schedule *Viz.*, I_1 (CRI, TL, BT, FL, ML, SD), I_2 (0.4 IW: CPE ratio), I_3 (0.6 IW: CPE ratio), I_4 (0.8 IW: CPE ratio) and I_5 (1.0 IW: CPE ratio) in randomized block design (RBD) within four replications. The number of days to attain various phenophases was determined from randomly selected five plants (with followed the sampling method) in all the plots visually by the number of days taken from the sowing date to attain respective phenophases up to maturity. Maximum and minimum temperatures used for study were taken from agro meteorological observatory that is near from the experimental site. The growing degree days (GDD) and heliothermal unit (HTU) was calculated according to the formula of Rajput (1980) and photothermal and relative temperature disparity (RTD) unit was calculated by using the formula of Major *et al.*, (1975) for different phenophases of wheat [viz. Crown root initiation (CRI), tillering (TL), booting (BT), anthesis (AT), milking (ML), dough stage (DS) and physiological maturity (PM).

$$GDD = \sum_{i=1}^{n} \frac{[T\max + T\min]}{2} - Tb$$

Where

Tmax= Maximum Temperature (^{0}C)

Tmin= Minimum Temperature (^{0}C)

Tb= Base Temperature

$$HTU = \sum_{i=1}^{n} GDD \times SSH$$

$$PTU = \sum_{i=1}^{n} GDD \times Daylength$$

$$RTD = \sum_{i=1}^{n} \frac{T\max - T\min}{T\max} \times 100$$

PTI = GDD ÷ Growing days

GDD	Growing Degree Days (^{0}C day)
HTU	Heliothermal Units (^{0}C day)
PTU	Photothermal Units (^{0}C day)
RTD	Relative Temperature Disparity
PTI	Photothermal index (^{0}C day)
Tmax	Maximum temperature (°C)
Tmin	Minimum temperature (°C)
Tb	Base temperature (°C)
SSH	Bright sunshine hours (hrs/day)

Results and Discussion

Growing degree day (GDD)

The results were revealed that the agrometeorological indices i.e. growing degree day (GDD) from date of CRI to physiological maturity (PM) accounted higher with I_1 (CRI, TL, BT, FL, ML, DS) than I_4 (0.8IW: CPE) irrigation level while lowest GDD observed when crop irrigated with I_2 (0.4 IW: CPE) and I_3 (0.6 IW: CPE) irrigation level. Moreover from anthesis to physiological maturity higher GDD were recorded with I_1 irrigation level than the rest of treatments. At physiological maturity of the crop highest GDD (3532 ^{0}C day) was accounted with I_1 irrigation level than I_4 (3500 ^{0}C day) while lowest GDD were recorded in case of I_2 (3168 ^{0}C day) irrigation level (Table 1).

The different irrigation application during critical phenophases was very much influencing on grain size and its comparative economical weight along with boldness in size of grain in I_1 irrigation level treatment. The regular irrigation applied treatment (I1) were observed the vigorous plant with dark green in colour with quite higher leaf area index as well chlorophyll contain in the leaves and less reflectivity of PAR wave length at advance phases was observed in I^1. In the Table 1 showed the various phenophases attained the degree day. The higher GDD was observed at physiological maturity stage in all the irrigation levels.

Heliothermal units (HTU)

Heliothermal units (HTU) were gradually increased from CRI to physiological maturity in all the irrigation level. During the period of study among all the irrigation level maximum HTU was recorded with I_1 (CRI, TL, BT, FL, ML, DS) irrigation level 32759 0C day while the lowest HTU were recorded (29563 0 C day) in case of irrigation level I_2 (Table 2). The HTU were found at par during different phenophases with all irrigation level. The slandered deviation were observed quite increasing trend from CRI to physiological maturity (PM) in all irrigation levels.

Photothermal units (PTU)

Photothermal units (PTU) from CRI to booting (BT) stage accounted higher with I_1 (CRI, TL, BT, FL, ML, DS) and I_5 (1.0 IW: CPE) irrigation level while lowest PTU were recorded with I_2 (0.4 IW: CPE) irrigation level. From anthesis to physiological maturity higher PTU were recorded with I_1 than rest of the treatments. At physiological maturity of wheat highest PTU (38652 ^{0}C days) with I_1 irrigation level while the lowest PTU were observed in case of wheat crop I_2 (34632 ^{0}C days) irrigation level. PTU decreased as irrigation level (IW: CPE) decreased (Table 3).

Table.1 Growing degree days (ºC day) required for various phenophases of wheat as affected by different irrigation levels

Irrigation levels	Phenophases						
	CRI	TL	BT	AT	ML	SD	PM
I_1(CRI, TL, BT, FL, ML, DS)	732	1325	1685	2081	2553	3055	3532
I_2 (0.4 IW: CPE)	732	1263	1557	2001	2460	2800	3168
I_3 (0.6 IW: CPE)	732	1294	1609	2032	2523	2952	3426
I_4 (0.8IW: CPE)	732	1294	1635	2058	2523	3020	3500
I_5 (1.0 IW: CPE)	732	1325	1660	2058	2553	3020	3463
Mean	732	1300	1629	2046	2522	2969	3418
S.D.	0.00	25.94	49.29	30.55	37.97	101.79	145.18
C.V.	0.00	0.02	0.03	0.01	0.02	0.03	0.04

Table.2 Heliothermal units (ºC day) required for various phenophases of wheat as affected by different irrigation levels

Irrigation levels	Phenophases						
	CRI	TL	BT	AT	ML	SD	PM
I_1(CRI, TL, BT, FL, ML, DS)	6684	12232	15182	18788	23310	28247	32759
I_2 (0.4 IW: CPE)	6684	11678	14255	18064	22401	25748	29563
I_3 (0.6 IW: CPE)	6684	11979	14607	18327	23025	27222	31809
I_4 (0.8IW: CPE)	6684	11979	14760	18576	23025	27900	32467
I_5 (1.0 IW: CPE)	6684	12232	14945	18576	23310	27900	32140
Mean	6684	12020	14750	18466	23014	27403	31748
S.D.	0.00	229.2	350.1	277.9	371.2	997.3	1271.9
C.V.	0.000	0.019	0.024	0.015	0.016	0.036	0.040

Table.3 Photothermal units (^{0}C day) required for various phenophases of wheat as affected by different irrigation levels

Irrigation levels	Phenophases						
	CRI	TL	BT	AT	ML	SD	PM
I_1(CRI, TL, BT, FL, ML, DS)	7890	14197	18035	22287	27466	33126	38652
I_2 (0.4 IW: CPE)	7890	13534	16661	21424	26435	30231	34632
I_3 (0.6 IW: CPE)	7890	13869	17220	21755	27130	31945	37406
I_4 (0.8IW: CPE)	7890	13869	17496	22038	27130	32729	38275
I_5 (1.0 IW: CPE)	7890	14197	17763	22063	27466	32729	37841
Mean	36.6	35.0	33.4	31.7	30.8	30.5	30.8
S.D.	0.00	0.09	0.31	0.09	0.01	0.05	0.22

Table.4 Relative temperature disparity (RTD) required for various phenophases of wheat as affected by different irrigation levels

Irrigation levels	Phenophases						
	CRI	TL	BT	AT	ML	SD	PM
I_1(CRI, TL, BT, FL, ML, DS)	47.8	55.7	59.5	63.4	62.1	61.9	59.3
I_2 (0.4 IW: CPE)	47.8	55.3	60.8	61.6	62.5	62.1	61.1
I_3 (0.6 IW: CPE)	47.8	55.7	60.4	63.0	63.3	60.9	61.7
I_4 (0.8IW: CPE)	47.8	55.7	59.9	62.3	62.9	60.5	59.3
I_5 (1.0 IW: CPE)	47.8	55.7	59.9	62.8	62.7	61.7	59.5
Mean	47.8	55.6	60.1	62.6	62.7	61.4	60.2
S.D.	0.00	0.18	0.50	0.69	0.45	0.69	1.14
C.V.	0.00	0.00	0.01	0.01	0.01	0.01	0.02

Table.5 Photo thermal index (°C day) required for various phenophases of wheat as affected by different irrigation levels

Irrigation levels	Phenophases						
	CRI	TL	BT	AT	ML	SD	PM
I_1(CRI, TL, BT, FL, ML, DS)	36.6	34.9	33.0	31.5	30.8	30.6	31.0
I_2 (0.4 IW: CPE)	36.6	35.1	33.8	31.8	30.8	30.4	30.5
I_3 (0.6 IW: CPE)	36.6	35.0	33.5	31.8	30.8	30.4	30.9
I_4 (0.8IW: CPE)	36.6	35.0	33.4	31.7	30.8	30.5	31.0
I_5 (1.0 IW: CPE)	36.6	34.9	33.2	31.7	30.8	30.5	30.9
Mean	36.6	35.0	33.4	31.7	30.8	30.5	30.8
S.D.	0.00	0.09	0.31	0.09	0.01	0.05	0.22
C.V.	0.00	0.00	0.01	0.00	0.00	0.00	0.01

Relative temperature disparity (RTD)

The effect of relative temperature disparity (RTD) was found no significant with different irrigation levels. Among irrigation levels values of RTD were increased from CRI to anthesis (AT) thereafter decreased up to physiological of crop but standard deviation higher at PM. Irrigation level I_3 and I_2 was accredited more RTD values than I_5, I_4 and I_1 irrigation level during the study period. The value of RTD increases with growing of the crop up to vegetative stage thereafter reduction in RTD was observed with physiological maturity of the crop; it might be due to lower value of night temperature and quite increased the day temperature. The high values of RTD were signal of higher mean temperature and comparatively low mean temperature (Table 4).

Photo thermal index (PTI)

Photo thermal index (PTI) for consecutive phenophases was computed and presented in table 5. PTI is expressed as degree days per growth day (Sastry and Chakravarty, 1982). Photo thermal index gradually decreased from emergence to physiological maturity (Kingra and Kaur 2012). Among the irrigation level the highest PTI value was found for I_1 (CRI, TL, BT, FL, ML, DS) and I_4 (0.8IW: CPE) and lowest value for I_2 (Table 5).

It was concludes that I_1 (CRI, TL, BT, FL, ML, DS) irrigation level was recorded maximum GDD, HTU, PTU and PTI as compare to other irrigation levels for wheat crop. Delayed irrigation application reduced the wheat production. So amount and time of irrigation water should s be kept in mind for higher yield. I_1 irrigation level proved to be beneficial for farmers to keep good harvest. The potential yield of any variety can attain where provided the efficient irrigations at critical growth stages without the situation of stress at Anand conditions.

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How to cite this article:

Nayak, M.K., Anil Kumar, Deepak Patil and Mohammad Ahatsham. 2017. Agrometeorological indices requirement for wheat crop under different irrigation levels. *Int.J.Curr.Microbiol.App.Sci.* 6(4): 1547-1553. doi: https://doi.org/10.20546/ijcmas.2017.604.190