*Original Research Article*

# Influence of irrigation scheduling (IW/CPE based) on physiological growth parameter and yield of wheat under different sowing dates

.


## ABSTRACT

Sowing time and irrigation play an important role to ensure higher production. Delay in sowing affects the growth and development of crop. Studying the effect of irrigation scheduling and sowing dates can provide a knowledge for improving production in late sowing conditions. A field experiment was conducted during the *rabi* season of 2020-21 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh to study the influence of irrigation scheduling on physiological growth parameters and yield of wheat under different sowing dates. The experiment comprised of 12 treatment combinations having three sowing dates, $3^{rd}$ December, $18^{th}$ December and $2^{nd}$ January in the main-plot and four Irrigation Water/ Cumulative Pan Evaporation (IW/CPE) based irrigation scheduling, viz. 1.0, 0.9, 0.8 and 0.7 in the sub-plot was analysed in split-plot design with three replications. The findings of present investigation revealed that the physiological growth parameters and yield was higher in $3^{rd}$ December sown date. Among the irrigation scheduling IW/CPE ratio 1.0 recorded significantly higher growth parameters and yield. The results of the present study concludes that adjusting sowing date with irrigation scheduling could assist in enhancing yield.



*Keywords: Growth parameters, Crop Growth Rate, Relative Growth rate, Net assimilation rate, Leaf area duration and Yield*


## 1. INTRODUCTION

Wheat (Triticum aestivum L.) is one of the most important cereal eaten in various forms in the world and is grown on 215 mha area with production of 765 mt in the world [1]. In India, it is grown in an area and production of 29 mha and 103 mt respectively, in the year 2019 with productivity around 3420 kg/ha [2]. In Madhya Pradesh, it covers 5.52 mha area during 2018-19 [3]. Wheat is a temperature sensitive crop. Delay in sowing exposes the crop to higher temperature that leads to accelerated maturity. Late sowing results in reduction in crop growth duration, it hastens crop phenological development [4] and hence, reduction in grain yield of wheat [5]. Extreme temperature during the grain filling stage has been identified as a major source of variation during wheat grain yield and quality characteristics [6]. Also, high temperature affects the net photosynthetic rate as it is sensitive for high temperature and hence, reduces the growth [7] and induces impairment of chlorophyll biosynthesis that results in less accumulation of chief photosynthetic pigment [8]. Hence, sowing time is crucial factor affecting the growth and yield of wheat. It has been observed that rise of 1˚C temperature above the optimum level during grain filling stage, decreased the grain weight by 232.56 mg plant$^{-1}$ day$^{-1}$ [9]. Furthermore, irrigation play important role in proper growth and development of plant. Inadequate soil water during early growth stages results in reduction of plant population, dry matter production, which ultimately results in yield reduction. The water shortage at stem elongation and heading stages significantly lowered wheat yield [10]. Effective irrigation scheduling aims to provide adequate moisture at critical growth stages of the crop and it is crucial for sowing window as it may act as an intervention to cope up the effect of warm weather conditions for late maturing crop. Hence, its efficient utilization is very important. Irrigation scheduling based on climatological approach (IW/CPE ratio) is a scientific and useful approach for the efficient utilization of water. This approach merits with special consideration of its simple operation and high-water use efficiency. Therefore, this study seeks to examine the effect of irrigation schedule based on IW/CPE ratio on physiological growth and yield of wheat under different sowing dates.

## 2. MATERIAL AND METHODS

A field experiment was conducted at Agricultural Engineering Farm, College of Agriculture Engineering, JNKVV, Jabalpur during the *rabi* season of 2020-21. The experiment comprised of twelve treatment combinations with three replications having three sowing dates, 3$^{rd}$ December, 18$^{th}$ December and 2$^{nd}$ January in main plots whereas in sub-plots, four irrigation schedules based on IW/CPE ratio viz., 1.0, 0.9, 0.8 and 0.7. The experiment was evaluated in split- plot design. The soil of experimental field was clay – loam in texture, neutral soil pH, medium in organic carbon content with NPK. Fertilizers were applied uniformly to all the treatment plots through urea, DAP and MOP @ 120:60:40 N: $P_2O_5$: $K_2O$. Half dose of nitrogen and full dose of phosphorus and potash was applied as a basal dose. Rest half dose of nitrogen was applied after first irrigation. During the period of experiment, the maximum temperature varied from 21.4 ºC to 38.3 ºC, and minimum temperature from 4.8 ºC to 16.5 ºC. The relative humidity (RH) varied from 11 to 88 percent during the crop season. The total rainfall received was 22 mm in 2 rainy days. The crop was exposed to total sunshine hours of 132.2 hours. The management practices for wheat (*Var*. MP3336) were done as per the recommendation of this region. For irrigation scheduling, a common come up irrigation was given just after the sowing after that water was applied as per the irrigation schedule based on IW/CPE approach i.e., 1.0, 0.9, 0.8 and 0.7 as per the formula by Parihar *et al*., [11]

$$\text{IW/CPE} = \frac{\text{Depth of irrigation (mm)}}{\text{cumulative pan evapouration (mm)}}$$

The irrigations were applied as per the treatments using 5.0 cm depth of irrigation. There is a difference in the number of irrigations between the IW/CPE ratios. The herbicide Clodinofop-propargyl 15 % + Metsulfuron methyl 1 %, was applied at the rate of 60+4g/ha at 30 days after sowing wheat. Various growth parameters viz., Leaf area Index, chlorophyll index, crop growth rate, relative growth rate, net assimilation rate, leaf area duration were taken at periodical intervals. These are worked out by using the following formulas

### 2.1 Leaf area Index

The leaf area ($m^2$) was measured with the help of leaf area meter (LI-COR, LI-3100C Area meter) and leaf area index (LAI) was calculated as per the formula given by, Watson [12]

$$\text{LAI} = \frac{\text{Total green leaf area of the plants (cm}^2)}{\text{Total ground area (cm}^2)}$$

### 2.2 Chlorophyll content

Chlorophyll content was taken with the help of handheld chlorophyll meter (atLeaf+, FT Green LLC, Wilmilngton, DE, USA) and Chlorophyll content was calculated by the equation, Padilla *et al*., [13]

$$\text{Chl} = 0.08 \times \text{atLEAF}^{1.63}$$

### 2.3 Crop growth rate (CGR) (g $m^{-2}$ $day^{-1}$)

Crop growth rate was calculated as per the formula suggested by Watson, [12] and is expressed in g $m^{-2}$ $day^{-1}$

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, $W_1$ = dry weight of plant (g $m^{-2}$) at $t_1$

$W_2$ = dry weight of plant (g $m^{-2}$) at $t_2$

$t_1$ = time of first observation

$t_2$ = time of second observation

### 2.3 Relative growth rate (RGR) (g $g^{-1}$$day^{-1}$)

It is worked out as per the formula given by Blackman, [14]

$$\text{RGR} = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where,

*ln* = natural log
$W_1$ = dry weight of plant at time $t_1$
$W_2$ = dry weight of plant at time $t_2$
$t_1$ = time of first observation
$t_2$ = time of second observation

### 2.4 Net assimilation rate (NAR) (g m$^{-2}$ day$^{-1}$)

It is determined by formula suggested by Nichiporovich [15]

$$\text{NAR} = \frac{(W_2 - W_1)(\ln L_2 - \ln L_1)}{t_2 - t_1}$$

Where, $L_1$ and $W_1$ are leaf area and dry weight of plant at $t_1$ and $L_2$ and $W_2$ are the leaf area and dry weight of plant at time $t_2$.

### 2.4 Leaf area duration (m$^2$ day)

It is worked out by the formula proposed by Watson [12]

$$\text{LAD} = \frac{(LA_2 - LA_1)\,(t_2 - t_1)}{2}$$

Where, $LA_1$ and $LA_1$ are leaf area at time $t_1$ and $t_2$

### 2.5 Statistical Analysis

The data obtained were statistically analysed using OPSTAT software available online at CCS Haryana Agriculture University [16]. The data were tabulated and analysed by using ANOVA [17]. The significant difference between treatment means were compared with critical differences at 5% levels of probability for F-test.

## 3. RESULTS AND DISCUSSION

### 3.1.1 Leaf area index

Leaf area is an important growth parameter that is related to crop yield. Leaf area index for different treatments is present in Table 1. Different sowing dates and IW/CPE ratio exerted a significant difference in all the treatment at different time intervals. It is observed that LAI increases with the increase in time period and reaches to maximum at 60 Days after sowing (DAS) after that declined due to senescence. Prasad [18] also observed decrease in LAI after 60 DAS upto 90 DAS. Among the sowing dates, significantly higher leaf area index (1.84) was recorded at 3$^{rd}$ December sowing date followed by 18$^{th}$ December (1.76) and 2$^{nd}$ December sowing date (1.32). Shivani *et al*., [19] also reported higher LAI than delayed sowing. Mishra *et al*., [20] found higher LAI in timely sowing of wheat than delayed sowing. Buttar *et. al*., [21] also noted decrease in LAI with the delay in sowing of wheat. Among the irrigation scheduling, IW/CPE ratio 1.0 observed higher LAI than 0.9, 0.8 and 0.7. This might be because of sufficient moisture availability by frequent irrigation at 1.0 IW/CPE. Throat [22] also noted more leaf area index with frequent irrigations. Butter *et al.,* [21] also noted increase in LAI with the increase in amount of irrigation.

### 3.1.2 Chlorophyll content (µg cm$^{-2}$)

Data pertaining to chlorophyll content (µg cm$^{-2}$) is presented in Table 1. It is clear from the table that chlorophyll content increased upto 60 DAS after that it declined marginally upto 90 DAS. This might be because of senescence of crop. Among the sowing dates, 3$^{rd}$ December sowing date (38.33) recorded significantly more chlorophyll content than 18$^{th}$ December (37.03) and 2$^{nd}$ January (34.09) sowing date. This might be because of temperature stress condition that resulted in lower chlorophyll content in the leaves. Throat [22] and Prasad [18] also reported decrease in chlorophyll content with the delay in sowing. Among the irrigation scheduling, IW/CPE ratio 1.0 recorded more chlorophyll content than 0.9, 0.8 and 0.7. This might be because of sufficient moisture availability due to frequent irrigations in IW/CPE ratio 1.0 that might have lowered the effect of temperature thereby increasing the chlorophyll content of the leaves. The results are in line with the findings of Thorat [22].

### 3.1.3 Relationship between Leaf area Index and grain yield

Regression analysis between grain yield with LAI and chlorophyll content showed a linear increase in yield with the increase in LAI and Chlorophyll content as shown in the fig 1. (a) and fig (b).

### 3.1.4 Relationship between LAI and grain yield

There was a positive significant relationship between leaf area and grain yield under different sowing dates and irrigation scheduling, fig 1 (a). This clearly shows that with the increase in leaf area index, the grain yield increases. The coefficient of determination shows 75 percent variation in grain yield. This might be because of reduction in vegetative phase due to raised temperature faced at delayed sowing as also observed by Ram *et al*., [23] and Ahmed *et al*., [24].

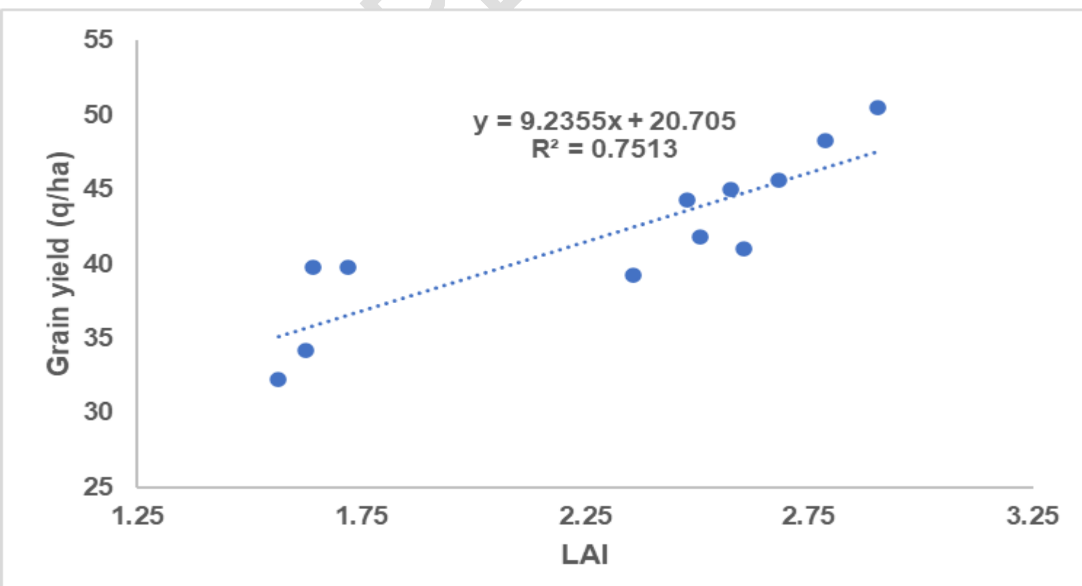
### 3.1.5 Relationship between Chlorophyll content (µg $cm^{-2}$) and grain yield (q/ha)

The graph clearly shows a positive significant relationship between chlorophyll content and grain yield under different sowing dates and irrigation scheduling, fig 1 (b). it is evident from yield graph that with the increase in chlorophyll content (µg $cm^{-2}$), the grain yield increases. The coefficient of determination shows 65 percent variation in grain yield. Throat [22], Prasad [18] and Jain [25], also observed more in chlorophyll content in timely sown crop than delayed sowing.

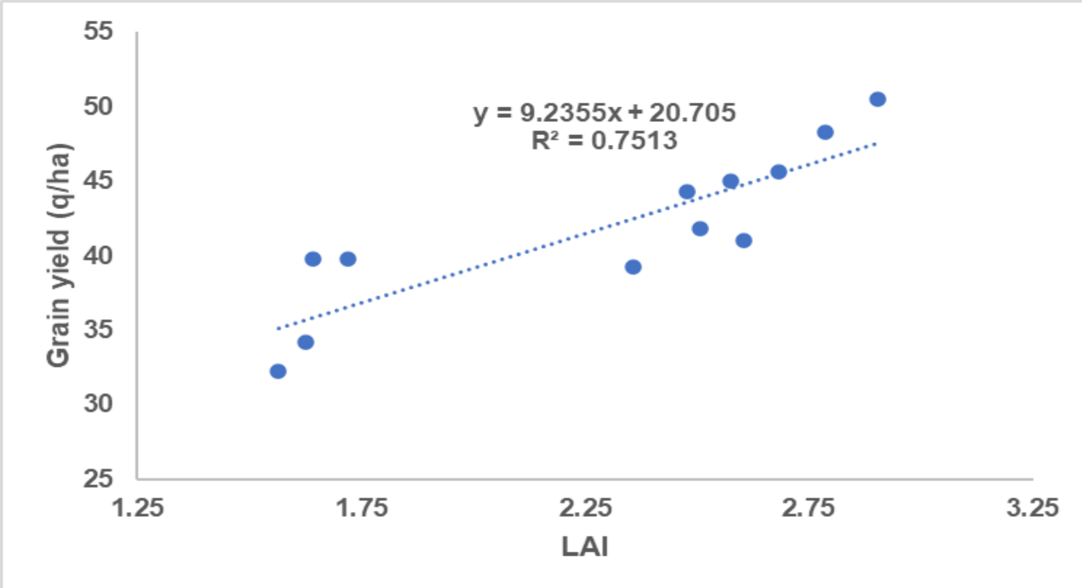
**Table 1. Influence of IW/CPE based irrigation scheduling and sowing dates on chlorophyll content and leaf area index**

| Treatments | Leaf area Index | | | Chlorophyll content (µg $cm^{-2}$) | | |
|---|---|---|---|---|---|---|
| | **30 DAS** | **60 DAS** | **90 DAS** | **30 DAS** | **60 DAS** | **90 DAS** |
| **Sowing dates** | | | | | | |
| **December 03** | 1.84 | 2.74 | 2.64 | 38.33 | 41.65 | 38.61 |
| **December 18** | 1.76 | 2.48 | 1.96 | 37.03 | 40.50 | 35.52 |
| **January 02** | 1.32 | 1.64 | 1.48 | 34.09 | 38.72 | 32.97 |
| **SE m±** | **0.03** | **0.02** | **0.02** | **0.4** | **0.1** | **0.1** |
| **CD (5%)** | **0.11** | **0.06** | **0.08** | **1.6** | **0.6** | **0.5** |
| **IW/CPE ratio** | | | | | | |
| **1.0** | 1.73 | 2.37 | 2.14 | 41.45 | 44.99 | 40.63 |
| **0.9** | 1.65 | 2.33 | 2.07 | 38.82 | 41.58 | 37.47 |
| **0.8** | 1.66 | 2.27 | 1.97 | 34.71 | 38.57 | 33.55 |
| **0.7** | 1.52 | 2.18 | 1.92 | 30.94 | 36.03 | 31.16 |
| **SE m±** | **0.05** | **0.02** | **0.01** | **0.5** | **0.3** | **0.4** |
| **CD (5%)** | **0.15** | **0.08** | **0.04** | **1.6** | **0.8** | **1.1** |






**(a)**




**(b)**

**Fig. 1 Relationship between grain yield and (a) Leaf Area Index (b) Chlorophyll content (μg cm$^{-2}$)**

### 3.2 Physiological Growth parameters

Data pertaining to physiological growth parameters is presented in Table 1. The data shows significant difference among the different treatments.

#### 3.2.1 Crop Growth rate (g m$^{-2}$ day$^{-1}$)

It is clear from the Table 2 that the crop sown at 3$^{rd}$ December recorded significantly higher Crop growth rate (9.05 gm$^{-2}$ day$^{-1}$) than 18$^{th}$ December and 2$^{nd}$January sowing date at 30-60 DAS. However, it was found to be non-significant at 60-90 DAS. This might be because of elevated temperature received by 18$^{th}$ December and 2$^{nd}$ January sowing date that resulted in reduction in crop growth duration thereby attaining early maturity, accumulating more dry matter accumulation in short period. Shivani et al., [19] and Lalita et al., [26] also observed similar results. Among the irrigation schedule, IW/CPE ratio 1.0 (9.27 and 8.23, respectively) recorded more CGR than other ratios at 30-60 DAS and 60-90 DAS. This might be because of sufficient moisture availability that resulted in accumulation of more dry matter, as also reported by Verma *et al*., [27].

#### 3.2.2 Relative Growth Rate (g m$^{-2}$ day$^{-1}$)

Results revealed that among the sowing dates, there is no significant different in RGR at 30-60 DAS. However, 2$^{nd}$ January (0.019) observed maximum RGR than the other sown dates at 60-90 DAS. This might be because of increased temperature that reduced crop growth duration. thereby, attaining successive growth stages earlier which increased dry matter accumulation in short duration as compared to 3$^{rd}$ December sowing. As also observed by Lie et al., [28] and Pareek et al., [29]. Among the irrigation scheduling, IW/CPE ratio 0.7 (0.019) observed more RGR than other irrigation schedules at 60-90 DAS. This might be because of reduction of growth period that resulted in less dry matter accumulation. Also, lack of moisture resulted in less dry matter accumulation. Pal et al., [30] also observed less dry matter accumulation due to the lack of moisture. Deo et al., [31], Chouhan et al., [32] and Buttar et al., [21] also similar results.

#### 3.2.2 Net Assimilation Ratio (g m$^{-2}$ day$^{-1}$)

Among the sowing dates, 2$^{nd}$ January (4.98) observed maximum NAR than the other sown dates at 30-60 and 60-90 DAS. This might be because of shorter length between the successive growth stages that resulted in more accumulation of dry matter in short period as also reported by Lalita et al., [27] and Pareek et al., [29]. Among the irrigation scheduling, IW/CPE ratio 1.0 (4.66) observed maximum NAR than the other irrigation schedules moisture at 30-60 DAS. However, it was non-significant at 60-90 DAS. Availability of sufficient moisture at 1.0 IW/CPE ratio might have increased the crop growth duration that resulted in more vegetative phase. But with the moisture stress condition resulted in early attaining the successive growth stages in limited period thereby increasing accumulation of dry matter. As also reported by Pareek et al., [29].

### 3.2.4 Leaf area Duration ($cm^2$ day)

Crop sown at 3rd December observed more LAD at 30-60 DAS and 60-90 DAS than 18th December and 2nd January sowing dates. This might be because of more leaf area that increased more photosynthetic activity per unit leaf area that leads to more LAD as also reported by Prasad [18]. Among the irrigation scheduling, IW/CPE ratio 1.0 observed maximum LAD than 0.9, 0.8 and 0.7 IW/CPE ratio. This might be sufficient moisture availability at 1.0 that contributed to fully turgid and open leaves thereby increasing photosynthetic activity of the plants. This also resulted in higher dry matter accumulation. Verma et al., [27] also observed that irrigation applied at 0.9 IW/CPE ratio recorded maximum values of growth indices.

### 3.3 Grain yield

Different sowing dates and IW/CPE ratios brought about significant variations in yield of wheat. Crop sown on 3rd December registered maximum yield (46.37 q/ha). Among the irrigation scheduling, IW/CPE ratio 1.0 registered maximum yield (45.10 q/ha) than other ratio and was at par with 0.9 irrigation schedule. This could be because of suitable conditions and moisture availability that favoured proper growth and development of plant thereby increasing yield. As also reported by Throat et al., [33], Jain [24], Buttar et al. [21], Prasad et al., [8], and Lanjhewar et al., [34].

**Table 2. Influence of IW/CPE based irrigation scheduling and sowing dates on chlorophyll content and leaf area index**

| Treatments | Crop growth rate ($g\ m^{-2}\ day^{-1}$) | | Relative growth rate ($g\ m^{-2}\ day^{-1}$) | | Net assimilation rate ($g\ m^{-2}\ day^{-1}$) | | Leaf area duration ($cm^2$ day) | |
|---|---|---|---|---|---|---|---|---|
| | **30-60 DAS** | **60-90 DAS** | **30-60 DAS** | **60-90 DAS** | **30-60 DAS** | **60-90 DAS** | **30-60 DAS** | **60-90 DAS** |
| **Sowing dates** | | | | | | | | |
| December 03 | 9.05 | 8.04 | 0.038 | 0.016 | 3.95 | 2.98 | 688697 | 808827 |
| December 18 | 7.91 | 7.42 | 0.037 | 0.016 | 3.74 | 3.35 | 637108 | 667775 |
| January 02 | 7.29 | 8.26 | 0.039 | 0.019 | 4.98 | 5.31 | 445779 | 469055 |
| **SE m ±** | **0.14** | **0.17** | **0.001** | **0.000** | **0.08** | **0.08** | **881.4** | **4017.5** |
| **CD (5%)** | **0.57** | **NS** | **NS** | **0.002** | **0.31** | **0.34** | **3553.6** | **16196.9** |
| **IW/CPE ratio** | | | | | | | | |
| 1.0 | 9.27 | 8.23 | 0.038 | 0.016 | 4.66 | 3.85 | 616487 | 678315 |
| 0.9 | 8.43 | 7.96 | 0.038 | 0.017 | 4.31 | 3.81 | 598673 | 660932 |
| 0.8 | 7.76 | 7.81 | 0.038 | 0.017 | 4.05 | 3.89 | 591506 | 638617 |
| 0.7 | 6.87 | 7.64 | 0.037 | 0.019 | 3.86 | 3.97 | 555446 | 616345 |
| **SE m ±** | **0.15** | **0.12** | **0.001** | **0.000** | **0.12** | **0.08** | **10000.9** | **5496.1** |
| **CD (5%)** | **0.44** | **0.37** | **NS** | **0.001** | **0.34** | **NS** | **29944.3** | **16456.3** |

## 4. CONCLUSION

From the present findings, it can be concluded that 3rd December sowing date and IW/CPE ratio 1.0 brought about significantly higher growth parameter and yield. However, delayed sowing with the decrease in irrigation level has negative effects on crop growth and on yield. Thus, adjusting sowing dates and scheduling irrigation could assist in enhancing growth parameters thereby increasing wheat yield.

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