# Effect of irrigation regimes and applied nitrogen levels on growth and physiological responses of ryegrass


## ABSTRACT

A field experiment was conducted at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat. The experiment was laid out in split-plot design with three replications. The treatments consisted of five levels of irrigation in main plot viz., $I_0$:Rainfed, $I_1$: Irrigation at critical growth stages, $I_2$: Irrigation at IW:CPE ratio of 1.0, $I_3$: Irrigation at IW:CPE ratio of 1.2 and $I_4$: Irrigation at IW:CPE ratio of 1.4 along with four levels of N- $N_0$: 0 kg N/ha, $N_1$: 30 kg N/ha, $N_2$: 60kg N/ha and $N_3$: 90 kg N/ha in sub- plots. The soil of the experimental site was sandy loam in texture, medium in organic carbon, available N and available $P_2O_5$, acidic in reaction and low in available $K_2O$.The result revealed that the highest leaf area index (LAI) recorded in irrigation at IW:CPE ratio of 1.4 at all the three cuts respectively during both the years. The crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) of ryegrass as influenced by different irrigation regimes were found to be non-significant at 30 DAS while at later growth stages i.e. 45 DAS, 60 DAS, 90 DAS and 120 DAS were significantlyinfluenced during both the years.The application of irrigation at IW:CPE of 1.4 produced higher value of CGR, RGR but the highest NAR was recorded in rainfed treatment. The data on LAI as influenced by different N levels was found to be significant in all three cuts. Application of 90 kg N/ha recorded the highest LAI. The CGR, RGR and NAR as influenced by different N levels were found to non significant at 30 DAS but significantly influenced at later growth stage i.e. 45 DAS, 60 DAS, 90 DAS and 120 DAS during boththe years. The highest data on CGR and RGR were recorded in 90 kg N/ha but the highest NAR was found in 0 kg N/ha.



**Key words:**leaf area index, crop growth rate, relative growth rate, net assimilation rate


## 1.INTRODUCTION

Ryegrass (*Loliummultiflorum*) is an important short duration annual winter forage species and adapted to wide variety of soil having high productivity with quick regeneration after cutting and giving superior quality forage [12]. Irrigation at 1.0 IW/CPE proved superior with respect to various growth parameters *viz.* plant height, dry matter accumulation, LAI, CGR and RGR which attributed to the higher green fodder and baby corn yield [1]. Scheduling of irrigation at 1.0 IW/CPE recorded maximum total dry matter (96.3 g plant$^{-1}$), plant height (171.0 cm), CGR (85.1 g m$^{-2}$ week$^{-1}$) and RGR (610 mg g$^{-1}$ week$^{-1}$) of maize over 0.6 and 0.8 IW/CPE [2]. Butter et al. [3] found higher LAI with the increase in amount of irrigation. Less dry matter accumulation due to the lack of moisture [4]. Hani et al. [5] found that increase in levels of nitrogen from 0 to 80 kg N/ha significantly increased the plant height, stem diameter and LAI of fodder maize.Application of 120 kg N ha$^{-1}$ gave significantly higher LAI and dry matter production than lower levels [6]. LAI increases with the increased rate of nitrogen application [7]. Significant increase in LAI with application of 210 kg N ha$^{-1}$ than lower levels [8]. Ashraf et al. [9] found significant increment in growth parameters such as plant height, LAI, CGR at all stages of crop growth with application of 250 kg N ha$^{-1}$ than lower levels. [10] found maximum LAI with maximum number of irrigations *i.e.* four which was higher than two and one irrigation. Efficient water supply during the growing season increased the leaf area of the crop; enabling it to

intercept most of the incoming radiation. The maximum LAI was observed with 200 kg N/ha followed by 150, 100, 50 kg N/ha and minimum LAI was found in control *i.e.* 0 kg N/ha.

## 2. MATERIALS AND METHODS

Experiment was conducted during 2017-2018 and 2018-2019 at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat. The experiment was laid out in a split-plot design with three replications. The treatments consisted of five levels of irrigation in main plot viz., Rainfed, Irrigation at critical growth stages, Irrigation at IW: CPE ratio of 1.0, Irrigation at IW:CPE ratio of 1.2 and Irrigation at IW:CPE ratio of 1.4 along with four levels of N- 0 kg N/ha, 30 kg N/ha, 60kg N/ha and 90 kg N/ha in sub-plots. Ryegrass variety Makhan grass at the seed rate of 20 kg/ha were dry seeded in the research plots. The nutrients were applied in the form urea, single super phosphate (SSP) and muriate of potash (MOP) as per requirement in the treatment. Nitrogen was applied in three split doses i.e. ½ of N is applied in final ploughing, ¼ at 1$^{st}$ cut and remaining ¼ at 2$^{nd}$ cut as per the treatment. All the phosphatic and potassic fertilizers were applied at the rate of 188 kg/ha of SSP and 50 kg/ha of MOP, respectively one day ahead of sowing ryegrass. Each sub-plot was provided with a uniform depth of 6 cm irrigation for ryegrass crop according to different IW:CPE ratios. The experiment was conducted consecutively for a period of two years.

The leaf area index(LAI) is calculated by dividing the leaf area per plant by land area occupied by the plant.

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

Crop growth rate(CGR) represents the dry weight of plants gained by a unit area of crop in a given time. It was expressed in g/m$^2$/day.

$$CGR = \frac{W_2 - W_1}{(t_2 - t_1)\,S}$$

Where,

$W_1$ and $W_2$ are plant dry weights at time $t_1$ and $t_2$ respectively

S is the land area over which dry matter was recorded.

The relative growth rate(RGR) of crops at time instant (t) is defined as the increase of plant material per unit weight per unit time. It is expressed in g/g/day.

$$RGR = \frac{\ln W_2 - \ln W1}{(t_2 - t_1)}$$

Where,

$W_1$ and $W_2$ are plant dry weight at time $t_1$ and $t_2$, respectively

Net assimilation rate(NAR) indirectly indicates the rate of net photosynthesis. It is expressed as g of dry matter production per day per m$^2$ leaf area.

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

Where,

$L_1$& $W_1$ = Leaf area and dry weight of the plant, respectively at time $t_1$

$L_2$& $W_2$= Leaf area and dry weight of the plant, respectively at time $t_2$

## 3. RESULTS AND DISCUSSION

### 3.1 Leaf Area Index (LAI)

The leaf area index (LAI) as influenced by irrigation regimes was found to be significant (Table 1) in all three cuts during both the years. Result revealed that leaf area index increased with increasing levels of irrigation regimes. The highest LAI recorded in irrigation at IW:CPE ratio of 1.4 being 1.24, 1.33, 1.28 and 1.26, 1.34, 1.29 at all the three cuts, respectively during both the years followed by irrigation at IW:CPE ratio of 1.2. Higher leaf area index found under increase levels of irrigation due to turgid cells and rapid cell production of plant leaves with more soil moisture. Similar findings were also observed by Akmal and Janssens[11]. The data on leaf area index (LAI) as influenced by different N levels was found to be significant in all three cuts i.e. 1st cut, 2nd cut and 3rd cut during both the years (Table 1). Application of 90 kg N/ha recorded the highest LAI being 1.16, 1.25, 1.21 and 1.19, 1.27, 1.24 at all the three cuts, respectively during both the years followed by 60 kg N/ha. The increased LAI due to increased number of leaves in unit area under this treatment. The lowest LAI was found in 0 kg N/ha in both the years.

**Table 1. Effect of irrigation regimes (I) and nitrogen levels (N) on Leaf Area Index (LAI) of ryegrass**

| **Treatments** | **LAI** | | | | | |
|---|---|---|---|---|---|---|
| | **1st Year** | | | **2nd Year** | | |
| | **1st cut** | **2nd cut** | **3rd cut** | **1st cut** | **2nd cut** | **3rd cut** |
| **Irrigation regimes (I)** | | | | | | |
| $I_0$ | 0.96 | 1.10 | 1.07 | 0.96 | 1.10 | 1.02 |
| $I_1$ | 1.01 | 1.13 | 1.13 | 1.07 | 1.18 | 1.14 |
| $I_2$ | 1.15 | 1.22 | 1.19 | 1.18 | 1.23 | 1.21 |
| $I_3$ | 1.17 | 1.27 | 1.24 | 1.20 | 1.30 | 1.25 |
| $I_4$ | 1.24 | 1.33 | 1.28 | 1.26 | 1.34 | 1.29 |
| S.Ed (±) | 0.048 | 0.029 | 0.04 | 0.049 | 0.027 | 0.044 |
| CD (P=0.05) | 0.11 | 0.07 | 0.10 | 0.11 | 0.061 | 0.10 |
| **Nitrogen levels (N)** | | | | | | |
| $N_0$ | 0.98 | 1.18 | 1.15 | 1.09 | 1.19 | 1.11 |
| $N_1$ | 1.14 | 1.19 | 1.18 | 1.11 | 1.21 | 1.15 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $N_2$ | 1.15 | 1.21 | 1.19 | 1.14 | 1.25 | 1.22 |
| $N_3$ | 1.16 | 1.25 | 1.21 | 1.19 | 1.27 | 1.24 |
| S. Ed (±) | 0.051 | 0.020 | 0.019 | 0.018 | 0.011 | 0.017 |
| CD (P=0.05) | 0.12 | 0.047 | 0.043 | 0.041 | 0.025 | 0.038 |
| **Interaction (I×N)** | | | | | | |
| S.Ed (±) | 0.11 | 0.045 | 0.041 | 0.040 | 0.024 | 0.037 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS |

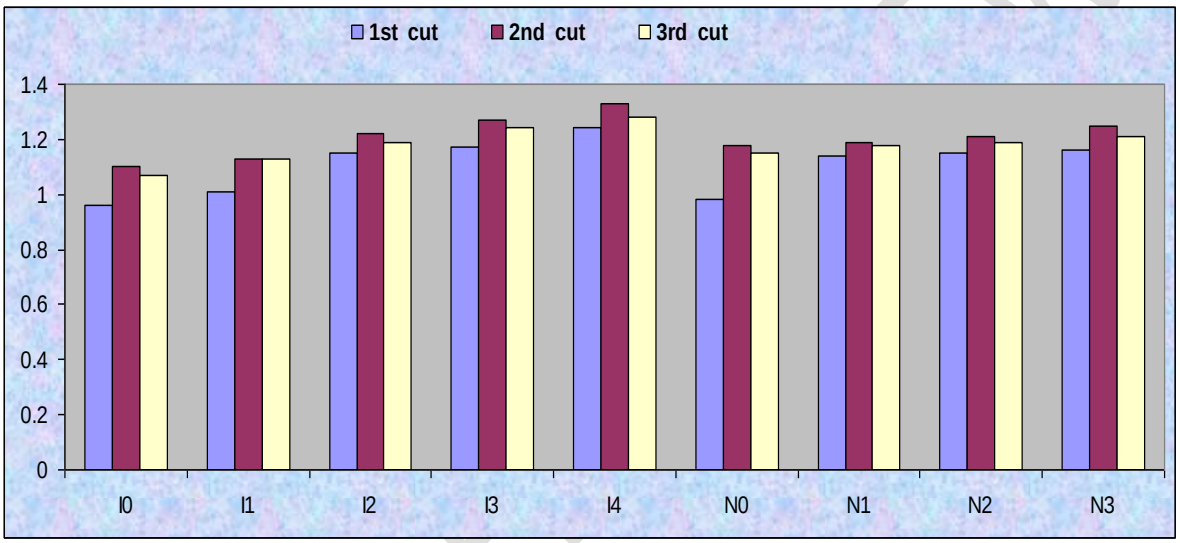


**Fig 1.**Indicating the effect of irrigation regimes and nitrogen levels on LAI of ryegrass (1st Year)

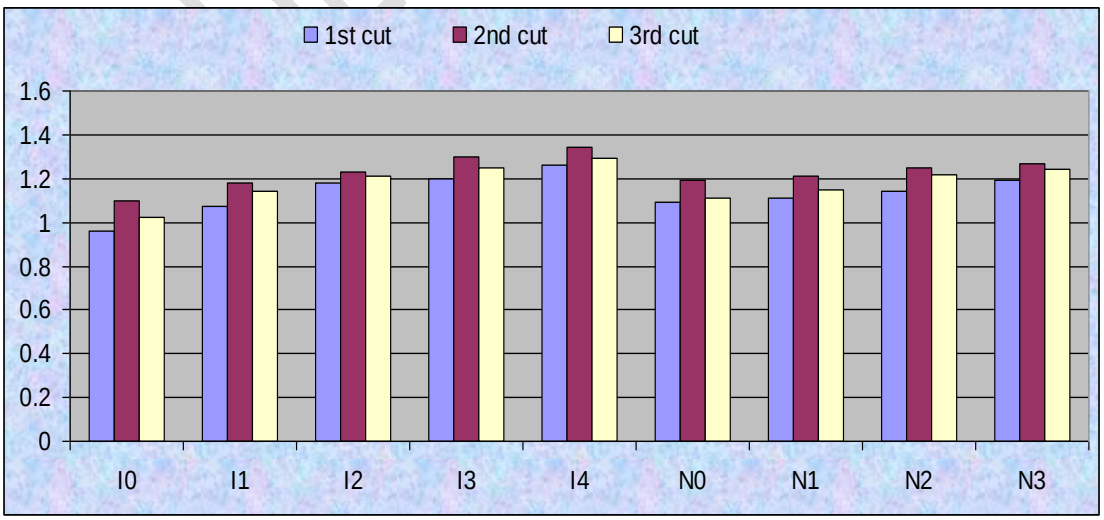


**Fig 2.**Indicating the effect of irrigation regimes and nitrogen levels on LAI of ryegrass (2nd Year)

### 3.2 Crop Growth Rate (CGR)

The crop growth rate (CGR) as influenced by different irrigation regimes was found to be non-significant at 30 DAS while at later growth stages i.e., at 45 DAS, 60 DAS, 90 DAS and 120 DAS, it was significantly influenced in both the years (Table 2). The application of irrigation at IW:CPE ratio of 1.4 produced higher value of crop growth rate (1.64 g/m$^2$/day, 3.91 g/m$^2$/day, 7.09 g/m$^2$/day, 7.62 g/m$^2$/day, 7.53 g/m$^2$/day and 1.67 g/m$^2$/day, 4.16 g/m$^2$/day, 6.86 g/m$^2$/day, 7.43 g/m$^2$/day, 7.86 g/m$^2$/day) at 30 DAS, 45 DAS, 60 DAS, 90 DAS and 120 DAS, respectively during both the years compared to other irrigation regimes.Adequate and timely supply of irrigation water which ensured cell turgidity and consequently higher meristematic activity leading to more foliage development, greater photosynthetic rate, and better growth of the plant. These results are in conformity with findings of Yadav et al. [12].The crop growth rate (CGR) as influenced by different nitrogen levels was found to be non-significant at 30 DAS but at later growth stages i.e. 45 DAS, 60 DAS, 90 DAS and 120 DAS, it was significantly effected during both the years (Table 2). The highest CGR(1.37 g/m$^2$/day, 3.06 g/m$^2$/day, 5.29 g/m$^2$/day, 6.07 g/m$^2$/day, 5.81 g/m$^2$/day and 1.45 g/m$^2$/day, 3.55 g/m$^2$/day, 5.18 g/m$^2$/day, 5.97 g/m$^2$/day, 6.02 g/m$^2$/day) was observed under the treatment of 90 kg N/ha at 30 DAS, 45 DAS, 60 DAS, 90 DAS and 120 DAS, respectively during both the years because increased dry matter accumulation under this treatment due to higher photosynthetic activity. The lowest crop growth rate was observed in 0 kg N/ha.

**Table 2.** Effect of irrigation regimes (I) and nitrogen levels (N) on Crop Growth Rate (CGR) of ryegrass

| **Treatments** | **CGR (g/m$^2$/day)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1st Year** | | | | | **2nd Year** | | | | |
| | **30 DAS** | **45 DAS** | **60 DAS** | **90 DAS** | **120 DAS** | **30 DAS** | **45 DAS** | **60 DAS** | **90 DAS** | **120 DAS** |
| **Irrigation regimes (I)** | | | | | | | | | | |
| $I_0$ | 0.93 | 1.63 | 2.78 | 3.17 | 3.02 | 1.17 | 1.72 | 2.89 | 3.32 | 3.35 |
| $I_1$ | 1.16 | 2.20 | 3.93 | 4.56 | 4.45 | 1.21 | 2.89 | 4.12 | 4.81 | 4.83 |
| $I_2$ | 1.27 | 2.46 | 4.15 | 5.68 | 5.16 | 1.32 | 3.12 | 4.35 | 5.62 | 5.36 |
| $I_3$ | 1.36 | 3.32 | 5.48 | 6.26 | 6.19 | 1.49 | 3.69 | 5.62 | 6.45 | 6.12 |
| $I_4$ | 1.64 | 3.91 | 7.09 | 7.62 | 7.53 | 1.67 | 4.16 | 6.86 | 7.43 | 7.86 |
| S.Ed (±) | 0.32 | 0.14 | 0.42 | 0.42 | 0.35 | 0.15 | 0.23 | 0.34 | 0.24 | 0.31 |
| CD (P=0.05) | NS | 0.33 | 0.97 | 0.96 | 0.80 | NS | 0.54 | 0.78 | 0.56 | 0.71 |
| **Nitrogen levels (N)** | | | | | | | | | | |
| $N_0$ | 1.20 | 2.51 | 4.11 | 4.85 | 4.82 | 1.33 | 2.69 | 4.36 | 5.18 | 5.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $N_1$ | 1.23 | 2.60 | 4.60 | 5.37 | 5.19 | 1.35 | 2.97 | 4.59 | 5.31 | 5.31 |
| $N_2$ | 1.29 | 2.65 | 4.75 | 5.54 | 5.27 | 1.36 | 3.26 | 4.94 | 5.63 | 5.67 |
| $N_3$ | 1.37 | 3.06 | 5.29 | 6.07 | 5.81 | 1.45 | 3.55 | 5.18 | 5.97 | 6.02 |
| S. Ed (±) | 0.13 | 0.19 | 0.40 | 0.40 | 0.32 | 0.08 | 0.23 | 0.29 | 0.27 | 0.31 |
| CD (P=0.05) | NS | 0.45 | 0.91 | 0.92 | 0.73 | NS | 0.54 | 0.68 | 0.62 | 0.73 |
| **Interaction (I×N)** | | | | | | | | | | |
| S.Ed (±) | 0.29 | 0.43 | 0.89 | 0.89 | 0.70 | 0.17 | 0.52 | 0.66 | 0.60 | 0.71 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

N.S: Non-significant

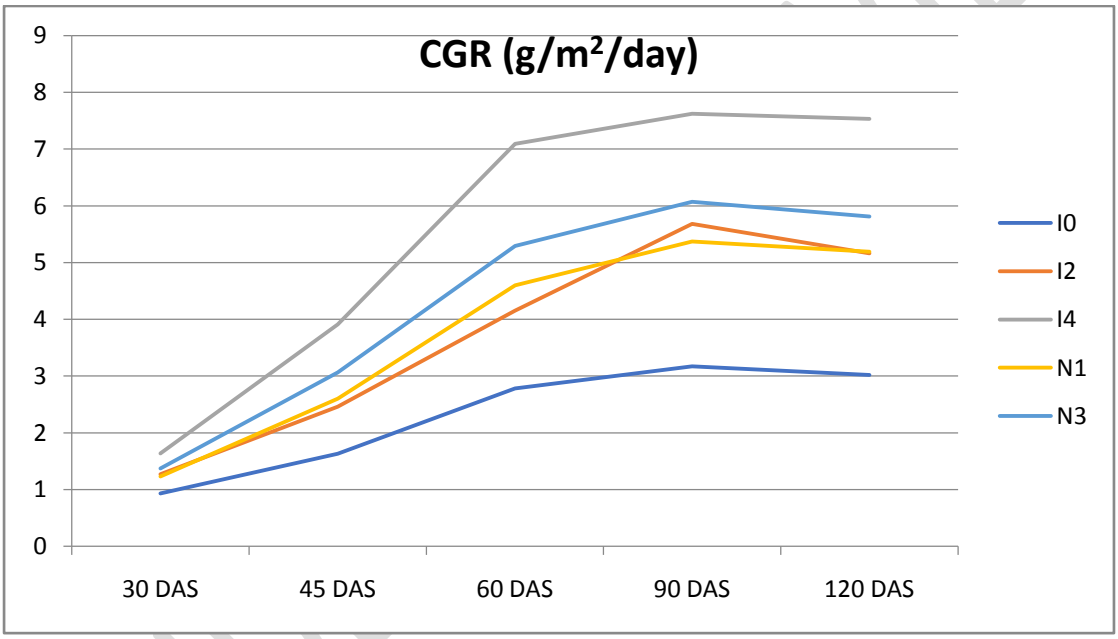


**Fig 3.**Crop growth rate line graphs of treatments $I_0$, $I_2$, $I_4$ $N_1$ and $N_3$ ($1^{st}$ Year)

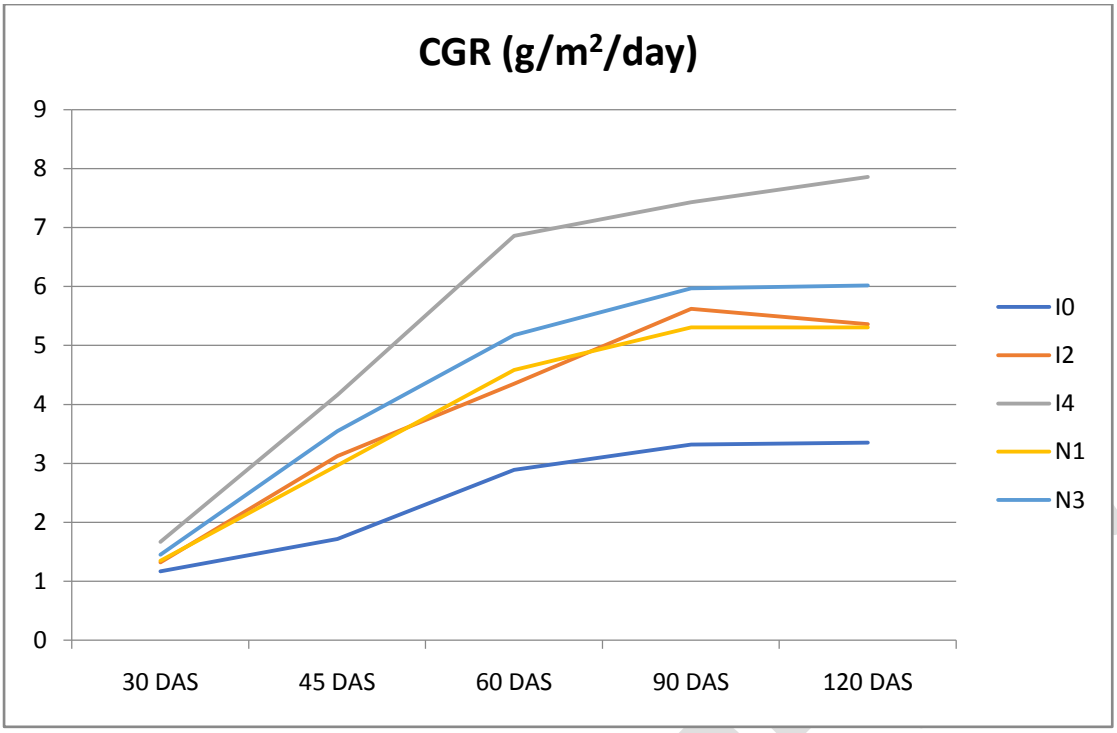


**Fig 4.**Crop growth rate line graphs of treatments $I_0$, $I_2$, $I_4$ $N_1$ and $N_3$ ($2^{nd}$ Year)

### 3.3 Relative Growth Rate (RGR)

The data on relative growth rate (RGR) as influenced by different irrigation regimes was found to be non-significant at 30 DAS while at later growth stages i.e. at 45 DAS, 60 DAS, 90 DAS and 120 DAS, it was significantly influenced during both the years (Table 3). The RGR reach its peak at 30 DAS and thereafter decreased in the later growth stages. Result revealed that the irrigation at IW:CPE ratio of 1.4 produced higher value of RGR (0.062 g/g/day, 0.059 g/g/day, 0.049 g/g/day, 0.051 g/g/day, 0.047 g/g/day and 0.064 g/g/day, 0.060 g/g/day, 0.052 g/g/day, 0.054 g/g/day, 0.050 g/g/day) followed by irrigation at IW:CPE ratio of 1.2 at 30 DAS, 45 DAS, 60 DAS, 90 DAS and 120 DAS, respectively during both the years. It might be due to greater biomass production under irrigation at IW:CPE ratio of 1.4. The lowest RGR was found under rainfed treatment. The data on relative growth rate (RGR) as influenced by different N levels was found to be non-significant at 30 DAS but at later growth stages *i.e*. 45 DAS, 60 DAS, 90 DAS and 120 DAS, it was significantly influenced during both the years are presented in Table 3. RGR was higher at 30 DAS and thereafter declined in the later growth stages. The highest RGR (0.060 g/g/day, 0.059 g/g/day, 0.050 g/g/day, 0.052 g/g/day, 0.048 g/g/day and 0.062 g/g/day, 0.060 g/g/day, 0.053 g/g/day, 0.054 g/g/day, 0.052 g/g/day) was recorded in the treatment of 90 kg N/ha during both the years at 30 DAS, 45 DAS, 60 DAS, 90 DAS and 120 DAS, respectively because the rate of accumulation of new dry mass per unit of existing dry mass was highest under the treatment of 90 kg N/ha.

**Table 3.** Effect of irrigation regimes (I) and nitrogen levels (N) on Relative Growth Rate (RGR) of ryegrass

| **Treatments** | **RGR (g/g/day)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1st Year** | | | | | **2nd Year** | | | | |
| | **30** | **45** | **60** | **90** | **120** | **30** | **45** | **60** | **90** | **120** |

| | DAS | DAS | DAS | DAS | DAS | DAS | DAS | DAS | DAS | DAS |
|---|---|---|---|---|---|---|---|---|---|---|
| **Irrigation regimes (I)** | | | | | | | | | | |
| $I_0$ | 0.053 | 0.049 | 0.043 | 0.044 | 0.040 | 0.054 | 0.051 | 0.044 | 0.046 | 0.042 |
| $I_1$ | 0.054 | 0.052 | 0.044 | 0.045 | 0.041 | 0.057 | 0.053 | 0.046 | 0.048 | 0.043 |
| $I_2$ | 0.055 | 0.054 | 0.045 | 0.047 | 0.043 | 0.059 | 0.056 | 0.047 | 0.049 | 0.046 |
| $I_3$ | 0.057 | 0.055 | 0.047 | 0.050 | 0.045 | 0.061 | 0.057 | 0.049 | 0.051 | 0.048 |
| $I_4$ | 0.062 | 0.059 | 0.049 | 0.051 | 0.047 | 0.064 | 0.060 | 0.052 | 0.054 | 0.050 |
| S.Ed (±) | 0.004 | 0.002 | 0.002 | 0.002 | 0.001 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 |
| CD (P=0.05) | NS | 0.004 | 0.004 | 0.004 | 0.003 | NS | 0.005 | 0.005 | 0.005 | 0.004 |
| **Nitrogen levels (N)** | | | | | | | | | | |
| $N_0$ | 0.052 | 0.050 | 0.040 | 0.044 | 0.040 | 0.055 | 0.051 | 0.042 | 0.046 | 0.043 |
| $N_1$ | 0.054 | 0.052 | 0.046 | 0.046 | 0.042 | 0.057 | 0.055 | 0.045 | 0.047 | 0.044 |
| $N_2$ | 0.057 | 0.055 | 0.048 | 0.048 | 0.043 | 0.061 | 0.056 | 0.050 | 0.050 | 0.045 |
| $N_3$ | 0.060 | 0.059 | 0.050 | 0.052 | 0.048 | 0.062 | 0.060 | 0.053 | 0.054 | 0.052 |
| S. Ed (±) | 0.005 | 0.003 | 0.003 | 0.003 | 0.003 | 0.004 | 0.003 | 0.002 | 0.003 | 0.005 |
| CD (P=0.05) | NS | 0.007 | 0.007 | 0.006 | 0.006 | NS | 0.006 | 0.005 | 0.006 | 0.005 |
| **Interaction (I×N)** | | | | | | | | | | |
| S.Ed (±) | 0.010 | 0.007 | 0.007 | 0.006 | 0.006 | 0.009 | 0.006 | 0.005 | 0.006 | 0.011 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

N.S: Non-significant

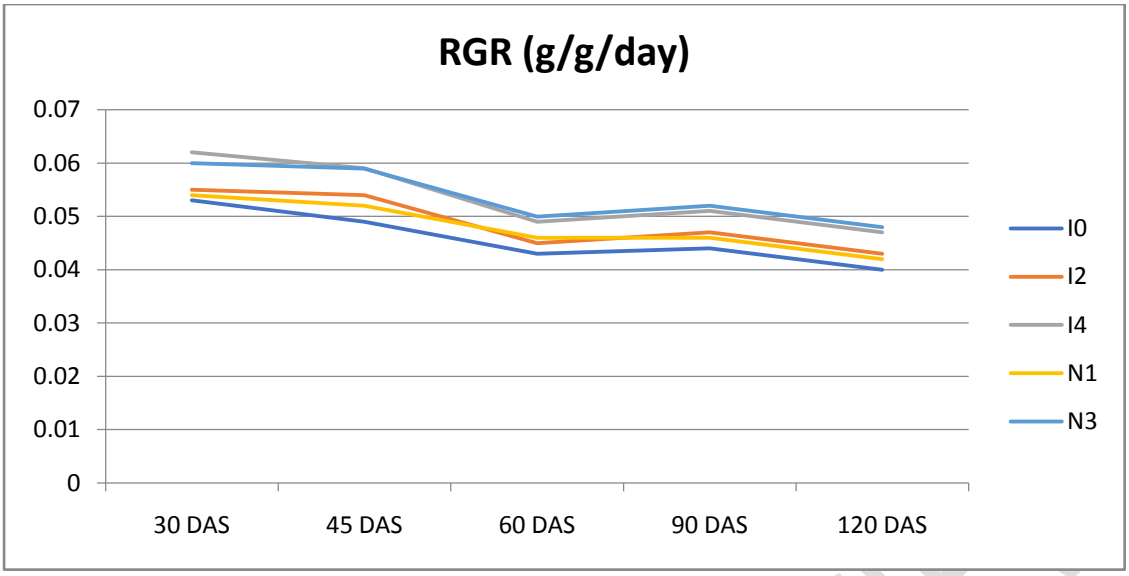


**Fig 5.**Relative growth rate line graphs of treatments $I_{0,}$ $I_{2,}$ $I_4$ $N_1$ and $N_3$ ($1^{st}$ Year)

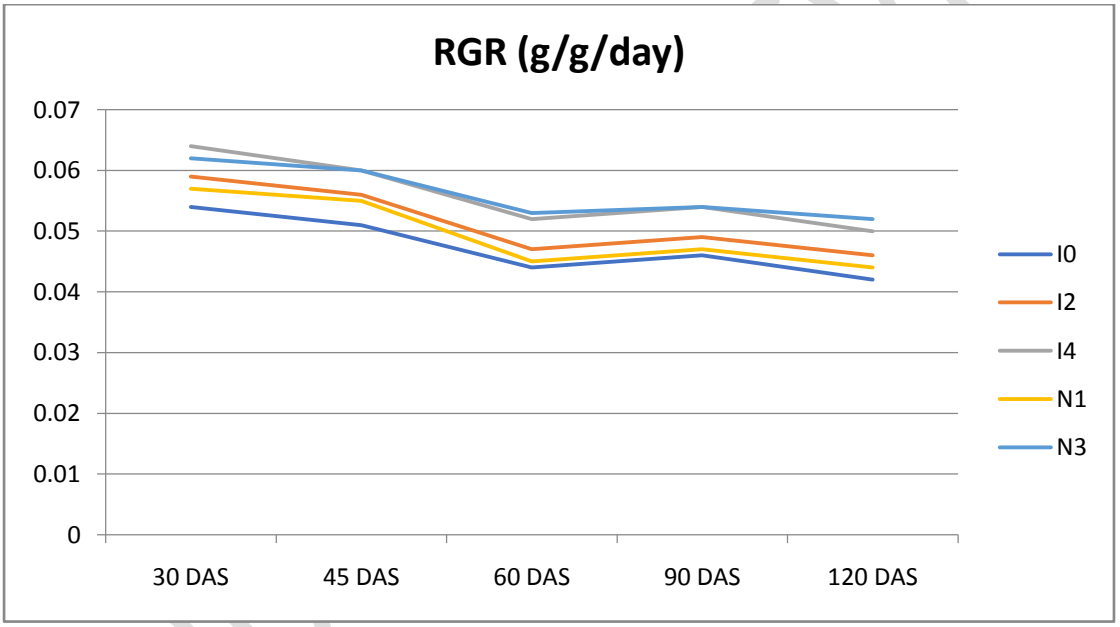


**Fig 6.**Relative growth rate line graphs of treatments $I_{0,}$ $I_{2,}$ $I_4$ $N_1$ and $N_3$ ($2^{nd}$ Year)

### 3.4 Net Assimilation Rate (NAR)

The data on net assimilation rate (NAR) of ryegrass as influenced by different irrigation regimes was found to be non-significant at 30 DAS, while at later growth stages i.e. 45 DAS, 60 DAS, 90 DAS and 120 DAS, it was significantly influencedduring both the years (Table 4). At the beginning of the growth stage NAR is more due to more penetration of light into canopy and higher rate of photosynthesis and less mutual shading of leaves. The highest NAR (0.025 $g/m^2$/day, 0.019 $g/m^2$/day, 0.017 $g/m^2$/day, 0.016 $g/m^2$/day, 0.018 $g/m^2$/day and 0.024 $g/m^2$/day, 0.017 $g/m^2$/day, 0.015 $g/m^2$/day, 0.014 $g/m^2$/day, 0.017 $g/m^2$/day) was recorded in rainfed treatment followed by irrigation at critical growth stages at 30 DAS, 45 DAS, 60 DAS, 90 DAS and 120 DAS during both the years, respectively. The lowest NAR was recorded in irrigation at IW:CPE ratio of 1.4 due to less penetration of light into canopy and more mutual shading of leaves on each other. The net assimilation rate (NAR) as influenced by different N levels was found to be non significant in

ryegrass at 30 DAS but it was significantly influenced at later growth stages i.e. 45 DAS, 60 DAS, 90 DAS and 120 DAS during both the years. The highest NAR (0.024 g/m$^2$/day, 0.018 g/m$^2$/day, 0.017 g/m$^2$/day, 0.015 g/m$^2$/day, 0.016 g/m$^2$/day and 0.022 g/m$^2$/day, 0.015 g/m$^2$/day, 0.013 g/m$^2$/day, 0.013 g/m$^2$/day, 0.015 g/m$^2$/day) was found in 0 kg N/ha at 30 DAS, 45 DAS, 60 DAS, 90 DAS and 120 DAS, respectively during both the years followed by 30 kg N/ha due to more penetration of light into canopy and less mutual shading of leaves. The lowest NAR was found in 90 kg N/ha.

**Table 4.** Effect of irrigation regimes (I) and nitrogen levels (N) on Net Assimilation Rate (NAR) of ryegrass

| **Treatments** | **NAR (g/m$^2$/day)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1st Year** | | | | | **2nd Year** | | | | |
| | **30 DAS** | **45 DAS** | **60 DAS** | **90 DAS** | **120 DAS** | **30 DAS** | **45 DAS** | **60 DAS** | **90 DAS** | **120 DAS** |
| **Irrigation regimes (I)** | | | | | | | | | | |
| $I_0$ | 0.025 | 0.019 | 0.017 | 0.016 | 0.018 | 0.024 | 0.017 | 0.015 | 0.014 | 0.017 |
| $I_1$ | 0.023 | 0.016 | 0.015 | 0.014 | 0.016 | 0.022 | 0.013 | 0.013 | 0.012 | 0.014 |
| $I_2$ | 0.020 | 0.014 | 0.014 | 0.013 | 0.015 | 0.021 | 0.012 | 0.010 | 0.010 | 0.013 |
| $I_3$ | 0.019 | 0.013 | 0.012 | 0.011 | 0.013 | 0.017 | 0.010 | 0.009 | 0.009 | 0.011 |
| $I_4$ | 0.018 | 0.012 | 0.009 | 0.008 | 0.010 | 0.016 | 0.009 | 0.007 | 0.007 | 0.009 |
| S.Ed (±) | 0.002 | 0.002 | 0.002 | 0.001 | 0.001 | 0.003 | 0.001 | 0.002 | 0.001 | 0.002 |
| CD (P=0.05) | NS | 0.005 | 0.004 | 0.003 | 0.003 | NS | 0.002 | 0.004 | 0.003 | 0.004 |
| **Nitrogen levels (N)** | | | | | | | | | | |
| $N_0$ | 0.024 | 0.018 | 0.017 | 0.015 | 0.016 | 0.022 | 0.015 | 0.013 | 0.013 | 0.015 |
| $N_1$ | 0.023 | 0.016 | 0.013 | 0.014 | 0.015 | 0.021 | 0.013 | 0.012 | 0.011 | 0.014 |
| $N_2$ | 0.019 | 0.014 | 0.012 | 0.011 | 0.014 | 0.019 | 0.011 | 0.010 | 0.010 | 0.012 |
| $N_3$ | 0.018 | 0.012 | 0.011 | 0.010 | 0.013 | 0.018 | 0.010 | 0.009 | 0.008 | 0.011 |
| S. Ed (±) | 0.003 | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 |
| CD (P=0.05) | NS | 0.005 | 0.004 | 0.004 | 0.003 | NS | 0.003 | 0.003 | 0.003 | 0.002 |
| **Interaction (I×N)** | | | | | | | | | | |
| S.Ed (±) | 0.008 | 0.004 | 0.004 | 0.004 | 0.002 | 0.005 | 0.003 | 0.002 | 0.003 | 0.002 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

N.S: Non-significant

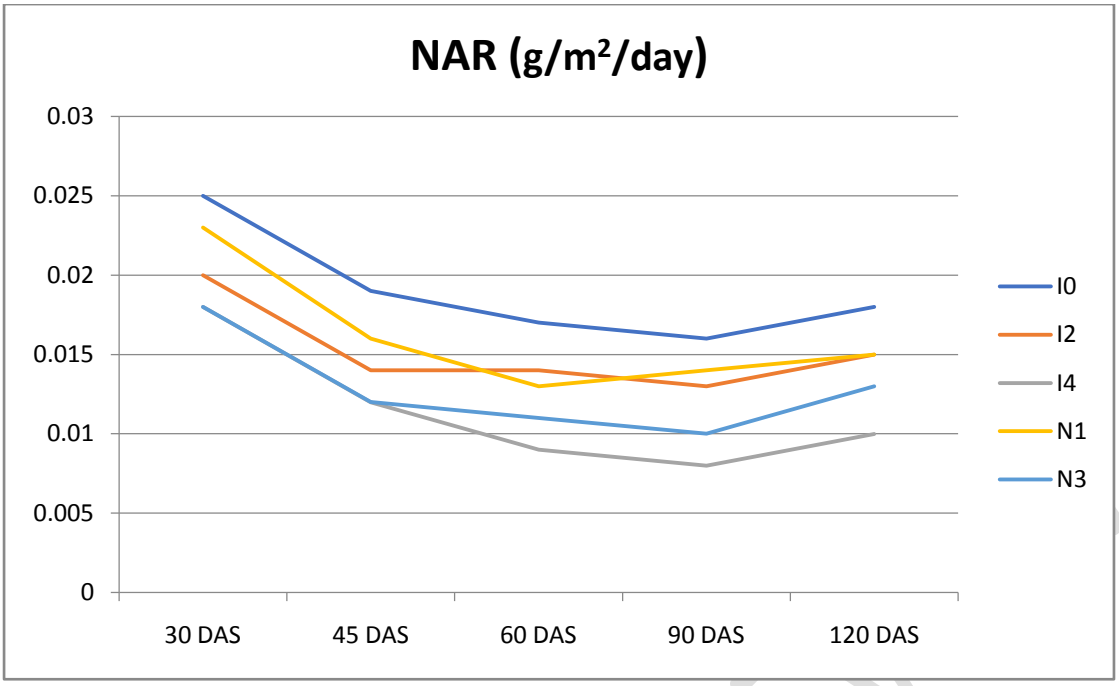


**Fig. 7.**Net assimilation rate line graphs of treatments $I_0$, $I_2$, $I_4$ $N_1$ and $N_3$ ($1^{st}$ Year)

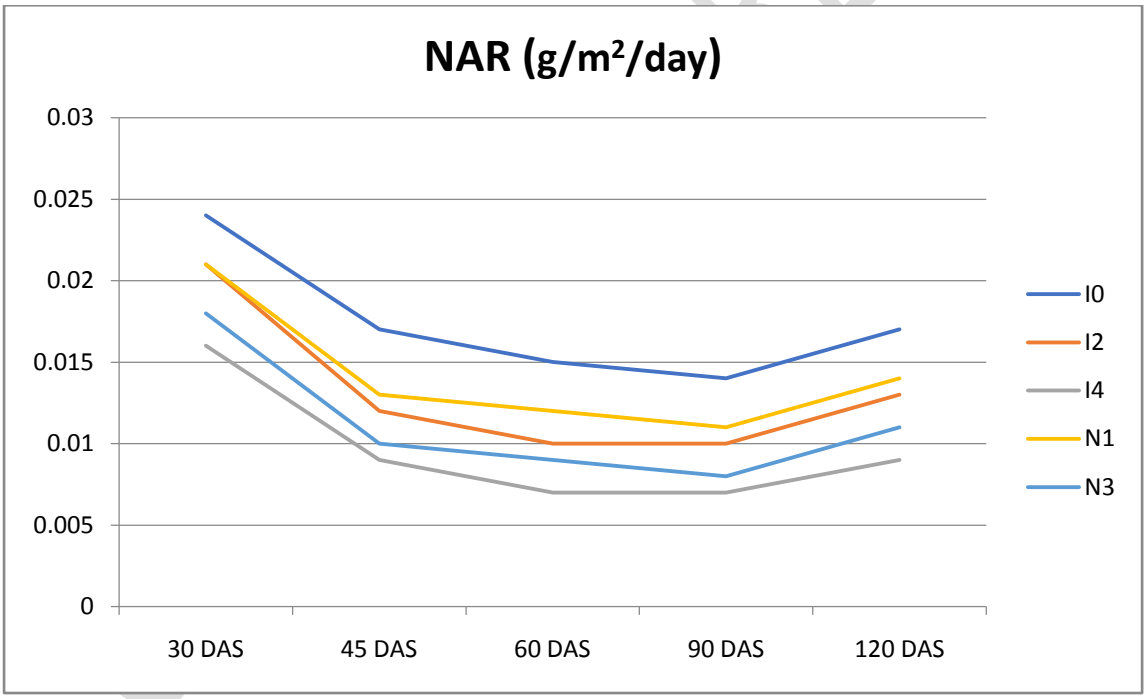


**Fig 8.**Net assimilation rate line graphs of treatments $I_0$, $I_2$, $I_4$ $N_1$ and $N_3$ ($2^{nd}$ Year)

**Interaction effect (I×N)**

The interaction effect between irrigation regimes and nitrogen levels was found to be non-significant in terms of physiological growth parameters at different growth stages of ryegrass during both the years.

## 4. CONCLUSION

From the experiment it was concluded that the physiological parameters in terms of LAI, CGR and RGR values were found to be higher in irrigation at IW:CPE ratio of 1.4 followed by irrigation at IW:CPE ratio of 1.2. But in case of NAR, higher values were recorded under rainfed treatment followed by irrigation at critical growth stages. The LAI, CGR and RGR recorded the highest value with application of 90 kg N/ha but the highest NAR was found in 0 kg N/ha followed by 30 kg N/ha and the lowest NAR was found in 90 kg N/ha.

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