International Journal of Plant & Soil Science

Volume 36, Issue 6, Page 860-869, 2024; Article no.IJPSS.117013
ISSN: 2320-7035

Effect of Irrigation Regimes and Applied Nitrogen Levels on Growth and Physiological Responses of Ryegrass

Nilotpal Hazarika [a*] and Karuna Kanta Sharma [b++]

[a] Department of Agronomy, Assam Agricultural University, Jorhat-785013, Assam, India.
[b] Advance Centre for IFS Research, Assam Agricultural University, Jorhat-785013, Assam, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i64693

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/117013

Original Research Article

Received: 14/03/2024
Accepted: 18/05/2024
Published: 24/05/2024

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: 60 kg 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 significantly influenced during both the years. The

[++]Retd. Chief Agronomist;
**Corresponding author: E-mail: nilotpalhazarika19@gmail.com;*

Cite as: *Hazarika, N., & Sharma, K. K. (2024). Effect of Irrigation Regimes and Applied Nitrogen Levels on Growth and Physiological Responses of Ryegrass. International Journal of Plant & Soil Science, 36(6), 860–869. https://doi.org/10.9734/ijpss/2024/v36i64693*

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 both the 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.

Keywords: leaf area index; crop growth rate; relative growth rate; net assimilation rate.

1. INTRODUCTION

Ryegrass (*Lolium multiflorum*) 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. 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 1st cut and remaining ¼ at 2nd 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.

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

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.

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

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, 2ndcut 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

N.S: Non-significant

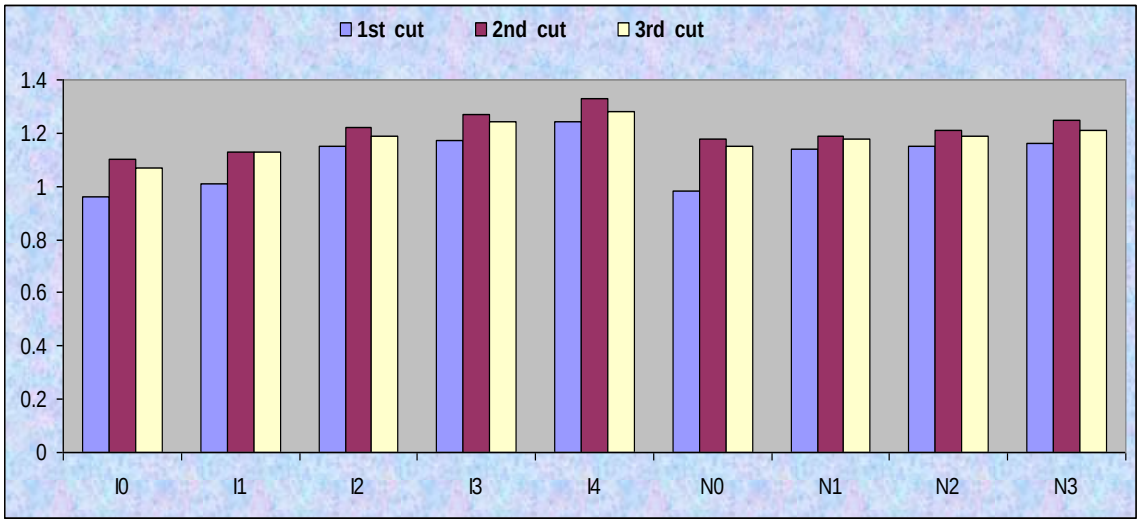

Fig. 1. Indicating the effect of irrigation regimes and nitrogen levels on LAI of ryegrass (1st Year)

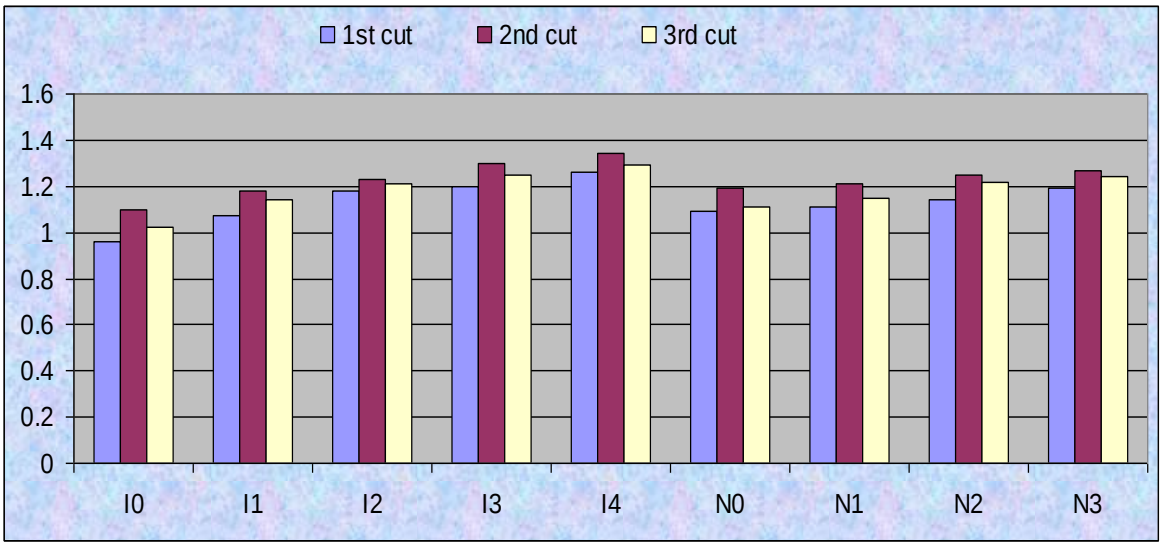

Fig. 2. Indicating the effect of irrigation regimes and nitrogen levels on LAI of ryegrass (2nd Year)

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

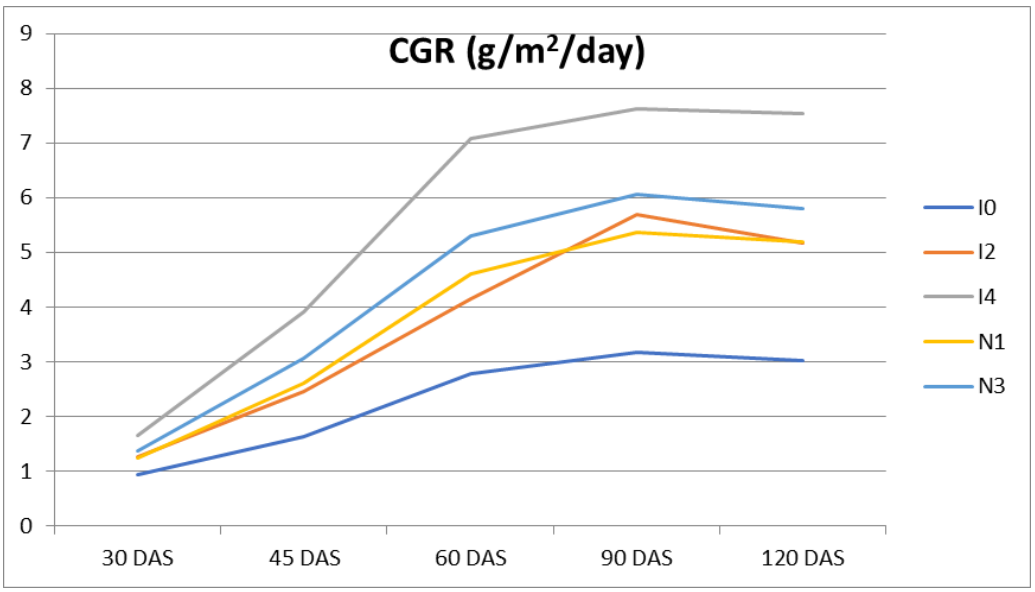

Fig. 3.Crop growth rate line graphs of treatments I_0, I_2, I_4, N_1 and N_3 (1st Year)

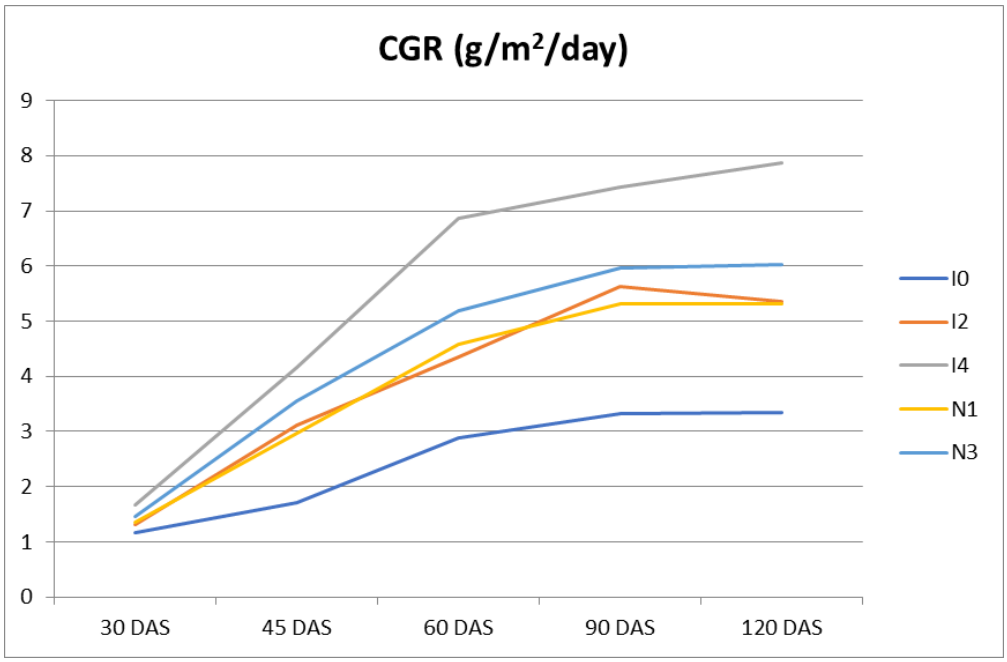

Fig. 4. Crop growth rate line graphs of treatments I_0, I_2, I_4, N_1 and N_3 (2nd Year)

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,

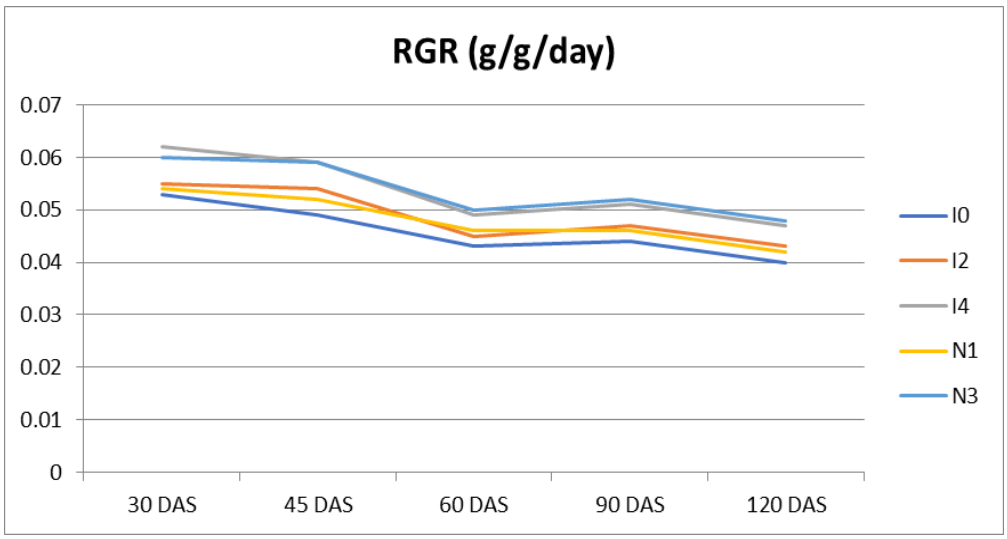

Fig 5. Relative growth rate line graphs of treatments I_0, I_2, I_4, N_1 and N_3 (1st Year)

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 DAS	45 DAS	60 DAS	90 DAS	120 DAS	30 DAS	45 DAS	60 DAS	90 DAS	120 DAS
Irrigation regimes (I)										
I_0	0.053	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

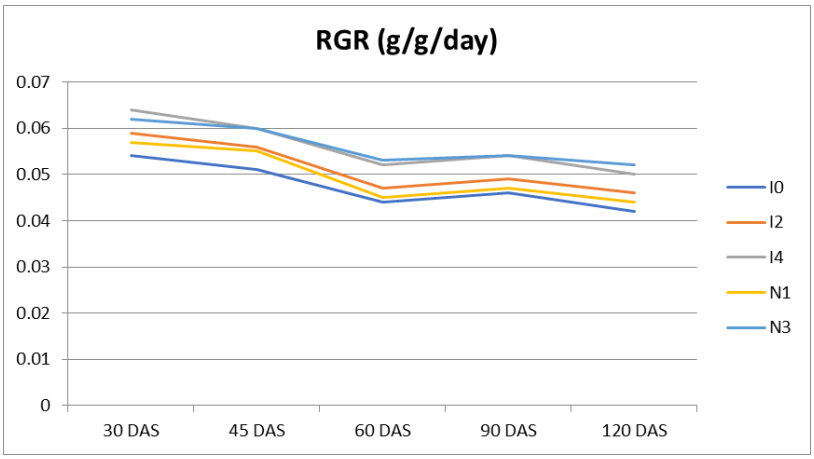

Fig. 6. Relative growth rate line graphs of treatments I_0, I_2, I_4, N_1 and N_3 (2nd Year)

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.

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 influenced during 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.

3.5 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.

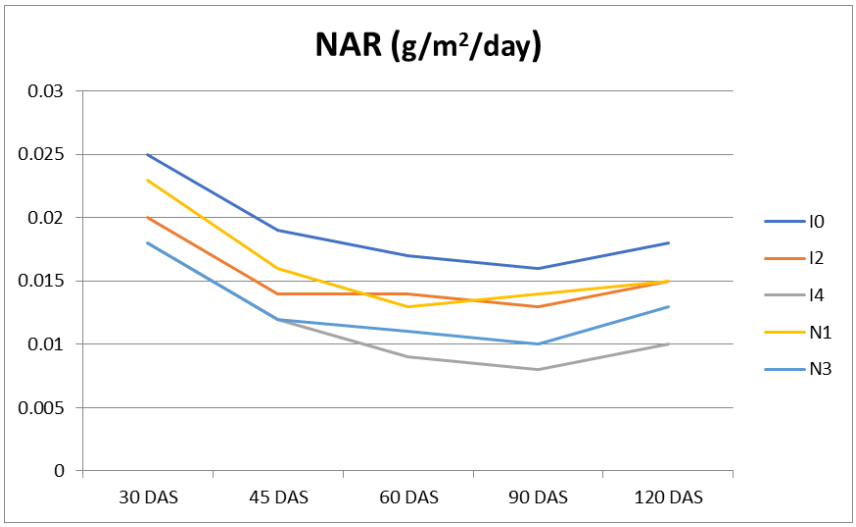

Fig. 7. Net assimilation rate line graphs of treatments I_0, I_2, I_4, N_1 and N_3 (1st Year)

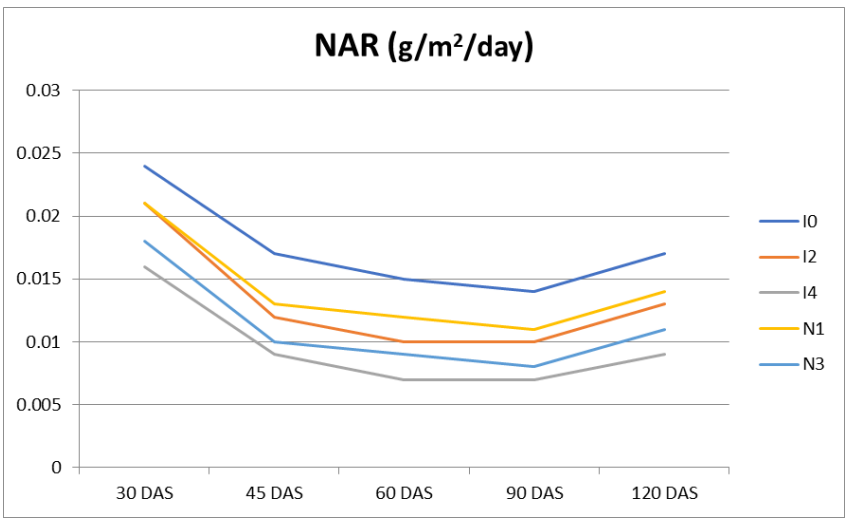

Fig 8. Net assimilation rate line graphs of treatments I_0, I_2, I_4, N_1 and N_3 (2nd Year)

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

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.

ACKNOWLEDGEMENT

Authors are thankful to Department of Agronomy, Assam Agricultural University, Jorhat for providing facilities to conduct the experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Meena RK, Tiwari RC, Meena VD, Charpota JL and Meena AK. Effect of Irrigation Management and Plant Population on the Performance of Summer Babycorn (*Zea Mays* L.). Int. J. Curr. Microbiol. App. Sci. 2017;6(7):2274-2282.
2. Hussaini MA, Ogunlela VB, Ramalan AA and Falaki AM. Growth and development of maize (*Zea mays* L.) in response to different levels of nitrogen, phosphorus and irrigation. Crop Res. 2001; 22(2):141-149.
3. Buttar PS, Kingra PK and Singh SP. Effect of Sowing dates, Irrigation and Mulching on Growth and Yield of Wheat. Agric Res J. 2018;55(2):243-250.
4. Pal S, Kumar S, Gangwar HK, Singh A and Kumar P. Effect of scheduling irrigation based on IW/CPE ratio on dry matter accumulation, yield attributes, yield and Economics of Wheat crop (*Trieticum aestivum* L.). Journal of Pharmacogynosy and Phytochemistry. 2020;9(4): 1946-949.
5. Hani A, Eltelib, Muna A and Ali EE. The effect of nitrogen and phosphorus fertilization on growth, yield and quality of fodder maize (*Zea mays* L). Journal of Agronomy. 2006;**5**(3):515-518.
6. Bindhani A, Barik KC, Garnayak LM, Mahapatra PL. Nitrogen management in baby corn (Zea mays L.). Indian J Agron. 2005;52:135-138.
7. Parija B. Performance of Kharif maize under different levels of farmyard manure and nitrogen. M.Sc. Thesis, Department of agronomy, Punjab agricultural University, Ludhiana, 2011.
8. Imran S, Arif M, Khan A, Khan MA, Shah W. Effect of Nitrogen Levels and Plant Population on Yield and Yield Components of Maize. Advances in crop science and technology. 2015;3:170.
9. Ashraf U, Salim MN, Sher A, Sabir S, Khana A, Pani S, Tangi X. Maize growth, yield formation and waternitrogen usage in response to varied irrigation and nitrogen supply under semi-arid climate. Turk J Field Crops. 2016;21(1):87-95.
10. Kumar M, RK Pannu and B Singh. Effect of irrigation regimes and nitrogen levels on phenology and grain yield of late sown wheat. Wheat and Barley Research. 2018;10(1):15-19.
11. Akmal M and Janssens MJJ. Productivity and light use efficiency of perennial ryegrass with contrasting water and nitrogen supplies. Field Crop Research. 2004;88:143-155.
12. Yadav RD, Pareek RG and Yadav RL. Effect of mulching and sulphur on growth and yield of mustard under varying levels of irrigation. Journal of Oilseeds Research. 2006;23(2):219-221.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/117013