

## Original Research Article

# Growth and yield parameters of ryegrass (*Lolium multiflorum*) as influenced by irrigation regimes and nitrogen levels

### ABSTRACT

A field experiment was conducted at the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat during 2017-2018 and 2018-2019. 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<sub>0</sub>: Rainfed, I<sub>1</sub>: Irrigation at critical growth stages, I<sub>2</sub>: Irrigation at IW: CPE ratio of 1.0, I<sub>3</sub>: Irrigation at IW:CPE ratio of 1.2 and I<sub>4</sub>: Irrigation at IW:CPE ratio of 1.4 along with four levels of N - N<sub>0</sub>: 0 kg N/ha, N<sub>1</sub>: 30 kg N/ha, N<sub>2</sub>: 60kg N/ha and N<sub>3</sub>: 90 kg N/ha in sub- plots. The soil of the experimental site was sandy loam in texture, acidic in reaction, medium in organic carbon, medium in available N, available P<sub>2</sub>O<sub>5</sub> and low in available K<sub>2</sub>O. The results revealed that different irrigation regimes significantly influenced the plant height, number of tillers/m<sup>2</sup>, number of leaves/m<sup>2</sup>, green fodder yield and dry matter yield of ryegrass at all the three cuts. The highest data recorded in irrigation at IW:CPE ratio of 1.4. The effect of levels of N on plant height, number of tillers/m<sup>2</sup>, number of leaves/m<sup>2</sup>, green fodder yield and dry matter yield of ryegrass were found to be significant at all three cuts in ryegrass. Application of 90 kg N/ha recorded the highest data than all other levels of nitrogen.

**Key words:** Ryegrass, IW:CPE ratio, N levels, green fodder yield, dry matter yield

### 1. INTRODUCTION

Ryegrass (*Lolium multiflorum*) is a rapid germinating, fast establishing plant. High palatability and digestibility make this species highly valuable for forage/livestock systems. It covers the ground which attributes to good erosion control. Growing annual ryegrass help to keep the nitrogen in the soil profile and available for the crop the following year. It produces biomass that will increase the soil organic matter and fertility. When growers changes to no-till, it takes approximately 5 years but adding ryegrass it reduces transition period by half. Annual ryegrass is having good seedling vigour that quickly forms a cover and suppress the weed.

Water and nitrogen play important role in the growth and yield of annual ryegrass. Gangaiah [1] found maximum plant height of oat with IW:CPE ratio of 0.9. Irrigation applied at three different stages of crop growth (20, 40 and 60 DAS) increased plant height, number of tillers per plant, number of leaves per tiller and green fodder yield of oats than other irrigation treatments [2]. Mitra *et al.* [3] observed that irrigation at 20 mm CPE significantly recorded the maximum plant height and total no. of tillers m<sup>-1</sup> row length of fodder oat compared to irrigation at 40 mm CPE and 60 mm CPE. Highest number of effective tillers of wheat with irrigation at 1:2 IW:CPE compared to 0.6 and 0.9 IW:CPE [4]. Hussein *et al.* [5] found that growth and yield of sorghum cultivated for forage or for seeds increased with increasing soil moisture. Jat *et al.* [6] reported that five irrigations (20, 40, 60, 80 and 100 DAS) gave

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significantly higher total green and dry fodder yield of oat over two (20 and 60 DAS), three (20, 40 and 60 DAS) and four (20, 40, 60 and 80 DAS) irrigations. Amanullah *et al.*[7] studied four surface irrigations level *i.e.* IW/CPE ratio of 0.4, 0.6, 0.8 and 1.0. They found that 0.6 and 0.8 IW/CPE ratio irrigation rates statistically at par for fodder yields. Agrawal *et al.*[8] found that irrigation at IW:CPE of 1.1 recorded higher green fodder, dry matter and crude protein yield of oats. Patel *et al.*[9] observed that irrigation at 1.1 IW:CPE with 80 mm produced significantly the highest green forage yield of lucern and remained at par with 0.9 IW:CPE. Nitrogen plays an important role in vegetative growth of grasses and their forage productivity. Marino *et al.* [10] and Lippke *et al.*[11] reported that annual ryegrass yield is generally increases with fertilizer nitrogen application rates, but optimum nitrogen level differ from site to site. Sharifi and Taghizadeh [12] reported that increase in levels of N application increased plant height in fodder maize. Increasing levels of nitrogen upto 160 kg ha<sup>-1</sup> improved the plant height and number of tillers of oats [13]. Application of nitrogen significantly increased the growth and yields of fodder oat. Application of 100 kg N ha<sup>-1</sup> recorded maximum plant height (103.3 cm) and number of leaves per plant (25.7/plant) which was at par with 80 kg N ha<sup>-1</sup> with respect to plant height but significantly superior to rest of levels [14]. Godara *et al.* [15] reported that increasing levels of nitrogen from 40 to 120 kg ha<sup>-1</sup> significantly influenced all growth parameters of oat but leaf:stem ratio and tillers numbers per metre row length were increased upto 80 kg N ha<sup>-1</sup>. Hasan *et al.*[16] found that plant characteristics such as plant height, no. of branches/plant of oat were increased with the increasing levels of N fertilizer. Aslam *et al.*[17] found higher fodder yield of maize with increase in nitrogen level up to 150 kg/ha. Rawat and Agrawal [14] reported that application of 100 kg N ha<sup>-1</sup> recorded maximum green fodder yield (361.5 q ha<sup>-1</sup>) and dry matter yield (100.2 q ha<sup>-1</sup>) of fodder oat which was at par with 80 kg N ha<sup>-1</sup> but significantly superior to rest of the levels. Application of 240 kg N ha<sup>-1</sup> recorded significantly higher green fodder yield, dry matter yield and crude protein of maize [18]. Pradhan *et al.*[19] found that application of nitrogen at the rate of 120 kg/ha along with 40 kg/ha each of phosphorus and potassium produced the highest yield with desirable fodder quality of sorghum. Varella *et al.*[20] found that dry matter yield of annual ryegrass and N uptake increased consistently with N fertilizer applications and shoot nitrogen content decreased with accumulation dry matter yield and plant maturity. Increase in fertility level upto 150 kg N ha<sup>-1</sup> increased green and dry fodder yields of oat [21]. Mahdi *et al.*[22] reported that increase in N level from 60 to 120 kg/ha significant increase fodder yield of maize. The maximum dry fodder yield of fodder oat was recorded with application of 110 kg N ha<sup>-1</sup> (8709 and 9624 kg ha<sup>-1</sup>) during both first and second cuttings [23].

## 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

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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.  $\frac{1}{2}$  of N is applied in final ploughing,  $\frac{1}{4}$  at 1<sup>st</sup> cut and remaining  $\frac{1}{4}$  at 2<sup>nd</sup> 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 amount of irrigation water was measured as follows:

$$q = a \times d$$

Where,

q = quantity of water needed for each irrigation (m<sup>3</sup>)

a = area to be irrigated (plot size-18 m<sup>2</sup>)

d = depth of water (6 cm)

So, irrigation water applied in each irrigation to-

$$\begin{aligned} q &= 18 \text{ m}^2 \times 0.06 \text{ m} \\ &= 1.08 \text{ m}^3 \text{ plot}^{-1} \\ &= 1080 \text{ litre plot}^{-1} \end{aligned}$$

Average discharge rate of the pump = 3.5 l/sec

Therefore, time required to irrigate an individual plot was,

$$\begin{aligned} T &= \frac{\text{Amount of water}}{\text{Discharge rate of pump}} \\ &= 1080/3.5 \text{ l} \\ &= 308.57 \text{ sec} \\ &= 5 \text{ min } 14 \text{ sec} \end{aligned}$$

The field was irrigated as per required time (approximately 5 min) to supply required 1080 litres of water/plot in the plots with irrigation treatment.

### 3. RESULTS AND DISCUSSION

#### Plant height

Plant height was measured at all the three cuts of ryegrass. The data are presented in Table 1. Different irrigation levels significantly influenced the height of ryegrass at all the three cuts in both the years. The maximum plant height that was observed in irrigation at IW:CPE ratio of 1.4 was 70.66%, 59.24%, 104% and 65.55%, 60.55%, 103.59% higher than rainfed treatment at 1<sup>st</sup> cut, 2<sup>nd</sup> cut and 3<sup>rd</sup> cut, respectively in both the years. The lowest plant height was recorded under rainfed treatment. This may be due to the increased availability of moisture in the soil in IW:CPE ratio of 1.4 which resulted in increased uptake of nutrients which in turn resulted in increased plant height. The findings of Gangaiah [1] is in conformity

with the present findings. The effect of levels of N on plant height was found to be significant at all three cuts in ryegrass during both the years (Table 1). The highest plant height of 45.32 cm, 57.57 cm, 51.68 cm and 45.35 cm, 58.26 cm, 52.58 cm were recorded in the treatment receiving 90 kg N/ha (N<sub>3</sub>) at 1<sup>st</sup> cut, 2<sup>nd</sup> cut and 3<sup>rd</sup> cut during both the years, respectively which was significantly higher than other N levels i.e. 60 kg N/ha (N<sub>2</sub>), 30 kg N/ha (N<sub>1</sub>) and 0 kg N/ha (N<sub>0</sub>). The lowest value was found in N<sub>0</sub> treatment. Application of higher N levels directed the plant to more vigorous growth which ultimately reflected in plant height. These findings are in conformity with Hasan and Shah [13] and Hussein *et al.*[5].

**Table 1. Effect of irrigation regimes (I) and nitrogen levels (N) on plant height (cm) of ryegrass**

Treatments	Plant height (cm)					
	1 <sup>st</sup> Year			2 <sup>nd</sup> Year		
	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut
<b>Irrigation regimes (I)</b>						
I <sub>0</sub>	25.94	36.43	26.95	26.30	37.16	27.29
I <sub>1</sub>	32.23	42.66	39.67	32.66	43.62	40.31
I <sub>2</sub>	36.90	47.68	41.33	37.18	47.87	43.19
I <sub>3</sub>	39.55	50.93	48.65	39.88	53.08	50.41
I <sub>4</sub>	44.27	58.01	54.98	43.54	59.66	55.56
S.Ed (±)	1.72	2.15	1.23	1.52	1.97	1.11
CD (P=0.05)	3.98	4.95	2.83	3.50	4.54	2.56
<b>Nitrogen levels (N)</b>						
N <sub>0</sub>	23.22	29.05	29.07	23.38	29.56	30.26
N <sub>1</sub>	35.22	48.59	42.18	35.28	50.54	43.15
N <sub>2</sub>	39.35	53.37	46.33	39.63	54.74	47.41
N <sub>3</sub>	45.32	57.57	51.68	45.35	58.26	52.58
S. Ed (±)	1.29	0.98	1.13	1.16	1.18	1.10
CD (P=0.05)	2.97	2.26	2.62	2.68	2.73	2.53
<b>Interaction (I×N)</b>						
S.Ed (±)	2.88	2.19	2.54	2.60	2.65	2.46
CD (P=0.05)	5.88	5.06	5.85	5.31	5.40	5.01
CV (%)	9.86	5.70	7.34	8.88	6.72	6.94

**Table 2. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on plant height (cm) of ryegrass at 1<sup>st</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
No	18.60	16.83	25.33	26.20	29.13	23.22
N <sub>1</sub>	25.43	32.27	35.13	41.27	42.00	35.22
N <sub>2</sub>	28.73	39.03	37.87	41.20	49.93	39.35
N <sub>3</sub>	31.00	40.80	49.27	49.53	56.00	45.32
Mean	25.94	32.23	36.90	39.55	44.27	35.78
		I		N		I×N
S.Ed (±)		1.72		1.29		2.88
CD (P=0.05)		3.98		2.97		5.88

**Table 3. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on plant height (cm) of ryegrass at 2<sup>nd</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
No	20.05	24.73	31.62	34.29	34.53	29.05
N <sub>1</sub>	38.23	44.66	48.60	51.09	60.35	48.59
N <sub>2</sub>	40.32	48.53	54.14	58.67	65.22	53.37
N <sub>3</sub>	47.14	52.70	56.37	59.68	71.95	57.57
Mean	36.43	42.66	47.68	50.93	58.01	47.14
		I		N		I×N
S.Ed (±)		2.15		0.98		2.19
CD (P=0.05)		4.95		2.26		5.06

**Table 4. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on plant height (cm) of ryegrass at 3<sup>rd</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
No	17.10	27.67	28.90	35.00	36.67	29.07
N <sub>1</sub>	25.71	41.40	42.07	47.33	54.40	42.18
N <sub>2</sub>	28.37	42.80	43.98	54.97	61.53	46.33

<b>N<sub>3</sub></b>	36.63	46.80	50.36	57.30	67.31	51.68
<b>Mean</b>	26.95	39.67	41.33	48.65	54.98	42.32
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		1.23		1.13		2.54
CD (P=0.05)		2.83		2.62		5.85

**Table 5. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on plant height (cm) of ryegrass at 1<sup>st</sup> cut (2<sup>nd</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	18.83	17.33	25.83	26.83	28.07	23.38
<b>N<sub>1</sub></b>	26.15	32.74	35.37	40.93	41.23	35.28
<b>N<sub>2</sub></b>	29.09	39.61	38.13	41.63	49.70	39.63
<b>N<sub>3</sub></b>	31.15	40.94	49.40	50.13	55.14	45.35
<b>Mean</b>	26.30	32.66	37.18	39.88	43.54	35.91
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		1.52		1.16		2.60
CD (P=0.05)		3.50		2.68		5.31

**Table 6. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on plant height (cm) of ryegrass at 2<sup>nd</sup> cut (2<sup>nd</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	20.60	25.73	31.05	35.54	34.87	29.56
<b>N<sub>1</sub></b>	40.12	46.31	49.69	53.33	63.26	50.54
<b>N<sub>2</sub></b>	40.47	49.09	54.21	62.56	67.40	54.74
<b>N<sub>3</sub></b>	47.43	53.34	56.54	60.89	73.11	58.26
<b>Mean</b>	37.16	43.62	47.87	53.08	59.66	48.28
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		1.97		1.18		2.65
CD		4.54		2.73		5.40

(P=0.05)						
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**Table 7. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on plant height (cm) of ryegrass at 3<sup>rd</sup> cut (3<sup>rd</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	17.37	28.86	30.81	36.59	37.67	30.26
N <sub>1</sub>	25.90	41.84	43.95	49.24	54.80	43.15
N <sub>2</sub>	28.78	43.49	45.85	56.73	62.22	47.41
N <sub>3</sub>	37.12	47.03	52.13	59.07	67.56	52.58
Mean	27.29	40.31	43.19	50.41	55.56	43.35
		I		N		I×N
S.Ed (±)		1.11		1.10		2.46
CD (P=0.05)		2.56		2.53		5.01

#### Interaction effect

The interaction effect of irrigation regimes and nitrogen levels was found to be significant in respect of plant height of ryegrass in all three cuts during both the years are presented in Table 2, Table 3, Table 4, Table 5, Table 6 and Table 7. The higher plant height were recorded with the application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha at 1<sup>st</sup> cut, 2<sup>nd</sup> cut and 3<sup>rd</sup> cut during both the years due to adequate soil moisture plant can greater use of available N than dry condition. Similar findings were reported by Akmal and Janssens [24]. The lowest value on plant height were recorded in rainfed treatment combined with 0 kg N/ha.

#### Number of tillers/m<sup>2</sup>

The effect of different levels of irrigation on number of tillers/m<sup>2</sup> of ryegrass was found to be significant during both the years (Table 8). Significantly highest numbers of tiller/m<sup>2</sup> of 232.91, 239.47, 234.95 and 234.07, 240.92, 240.04 has been recorded in irrigation at IW: CPE ratio of 1.4 in all the three cuts, respectively during both the years. In all cases of observations the numbers of tiller/m<sup>2</sup> increased with increasing levels of irrigation from IW:CPE ratio 1.0 to IW:CPE ratio 1.4. This can be due to greater availability of photosynthates and its translocation towards the formation of sink organs that resulted in formation of more no. of tillers. Jat *et al.* [6] also reported similar findings. Different nitrogen levels significantly influenced the number of tillers/m<sup>2</sup> of ryegrass in both the years (Table 8). The increased number of tillers/m<sup>2</sup> were found with increasing levels of nitrogen. The highest number of tillers/m<sup>2</sup> was found with the application of 90 kg N/ha which was significantly higher than other N levels. Application of 90 kg N/ha resulted in 95.05%, 109.48%, 108.19%

and 93.75%, 104.99%, 105.39% higher numbers of tiller/m<sup>2</sup> over 0 kg N/ha at 1<sup>st</sup> cut, 2<sup>nd</sup> cut and 3<sup>rd</sup> cut respectively, during both the years. The availability of nutrient in the soil increased with higher dose of nitrogen application which ultimately increased the availability and uptake of nutrient resulting in more numbers of tiller. Nitrogen fertilizer application may also be associated with a decrease in root:shoot ratio of plants and an increase in the allocation of substrate for shoot growth leading to an increased rate of photosynthesis leading to production of more tiller reported by Woledge and Pearse[25]. Jat *et al.*[6] found that application of 110 kg N ha<sup>-1</sup> gave significantly higher number of tillers m<sup>-1</sup> row length over 70 kg N ha<sup>-1</sup> but statistically at par with rest of treatment (90 kg N/ha). The improvement in nutritional status of plant might have resulted in greater synthesis of amino acids, proteins and other growth promoting substances which seems to have enhanced the meristematic activity and increased cell division and enlargement and their elongation resulted in more number of tillers.

**Table 8. Effect of irrigation regimes (I) and nitrogen levels (N) on tillers/m<sup>2</sup> of ryegrass**

Treatments	Tillers/m <sup>2</sup>					
	1 <sup>st</sup> Year			2 <sup>nd</sup> Year		
	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut
<b>Irrigation regimes (I)</b>						
I <sub>0</sub>	114.93	121.45	117.33	115.38	124.89	117.56
I <sub>1</sub>	149.25	151.64	148.43	146.82	157.79	151.91
I <sub>2</sub>	170.46	179.02	172.54	174.86	183.17	173.55
I <sub>3</sub>	188.56	201.98	207.18	203.32	212.39	209.93
I <sub>4</sub>	232.91	239.47	234.95	234.07	240.92	240.04
S.Ed (±)	3.97	7.41	10.19	10.15	7.99	10.59
CD (P=0.05)	9.16	17.09	23.50	23.40	18.42	24.42
<b>Nitrogen levels (N)</b>						
N <sub>0</sub>	109.07	107.01	104.83	112.83	111.11	107.50
N <sub>1</sub>	174.23	180.01	179.76	178.13	188.02	182.25
N <sub>2</sub>	188.85	203.66	201.50	189.98	208.45	203.85
N <sub>3</sub>	212.74	224.16	218.25	218.61	227.76	220.79
S. Ed (±)	8.06	8.62	6.36	8.05	8.16	7.14
CD (P=0.05)	18.60	19.88	14.67	18.57	18.81	16.47
<b>Interaction (I×N)</b>						
S.Ed (±)	18.03	19.28	14.22	18.00	18.24	15.97
CD (P=0.05)	36.79	39.33	29.02	36.73	37.20	32.58

CV (%)	12.90	13.21	9.89	12.61	12.15	10.95
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**Table 9. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on tillers/m<sup>2</sup> of ryegrass at 1<sup>st</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	80.57	66.35	133.60	98.73	166.10	109.07
N <sub>1</sub>	100.25	155.88	167.44	220.01	227.58	174.23
N <sub>2</sub>	124.40	182.92	172.64	214.29	250.00	188.85
N <sub>3</sub>	154.51	191.83	208.18	221.22	287.96	212.74
<b>Mean</b>	114.93	149.25	170.46	188.56	232.91	171.22
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		3.97		8.06		18.03
CD (P=0.05)		9.16		18.60		36.79

**Table 10. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on tillers/m<sup>2</sup> of ryegrass at 2<sup>nd</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	61.57	121.61	102.77	108.60	140.50	107.01
N <sub>1</sub>	104.63	120.00	215.20	199.93	260.29	180.01
N <sub>2</sub>	149.73	176.39	183.51	232.61	276.04	203.66
N <sub>3</sub>	169.86	188.55	214.59	266.77	281.06	224.16
<b>Mean</b>	121.45	151.64	179.02	201.98	239.47	178.71
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		7.41		8.62		19.28
CD (P=0.05)		17.09		19.88		39.33

**Table 11. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on tillers/m<sup>2</sup> of ryegrass at 3<sup>rd</sup> cut (1<sup>st</sup> Year)**

Nitrogen	Irrigation regimes (I)	Mean
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levels (N)	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	84.57	99.92	83.10	123.17	133.40	104.83
N <sub>1</sub>	108.38	147.22	189.73	206.20	247.27	179.76
N <sub>2</sub>	133.54	162.00	191.76	252.13	268.06	201.50
N <sub>3</sub>	142.81	184.58	225.58	247.21	291.06	218.25
Mean	117.33	148.43	172.54	207.18	234.95	176.08
		I		N		I×N
S.Ed (±)		10.19		6.36		14.22
CD (P=0.05)		23.50		14.67		29.02

**Table 12. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on tillers/m<sup>2</sup> of ryegrass at 1<sup>st</sup> cut (2<sup>nd</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	80.68	67.64	135.81	113.30	166.74	112.83
N <sub>1</sub>	100.76	157.05	169.66	234.35	228.84	178.13
N <sub>2</sub>	125.25	169.33	175.21	228.85	251.29	189.98
N <sub>3</sub>	154.84	193.24	218.77	236.78	289.40	218.61
Mean	115.38	146.82	174.86	203.32	234.07	174.89
		I		N		I×N
S.Ed (±)		10.15		8.05		18.00
CD (P=0.05)		23.40		18.57		36.73

**Table 13. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on tillers/m<sup>2</sup> of ryegrass at 2<sup>nd</sup> cut (2<sup>nd</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	65.07	122.81	106.81	119.05	141.80	111.11
N <sub>1</sub>	107.84	141.16	219.54	210.39	261.18	188.02
N <sub>2</sub>	153.05	177.39	187.40	245.15	279.26	208.45
N <sub>3</sub>	173.59	189.81	218.93	275.00	281.45	227.76

<b>Mean</b>	124.89	157.79	183.17	212.39	240.92	183.83
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		7.99		8.16		18.24
CD (P=0.05)		18.42		18.81		37.20

**Table 14. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on tillers/m<sup>2</sup> of ryegrass at 3<sup>rd</sup> cut (2<sup>nd</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	85.00	103.34	84.38	126.23	138.55	107.50
N <sub>1</sub>	108.48	150.97	190.58	208.74	252.46	182.25
N <sub>2</sub>	133.70	165.43	192.60	254.42	273.11	203.85
N <sub>3</sub>	143.07	187.89	226.63	250.32	296.04	220.79
<b>Mean</b>	117.56	151.91	173.55	209.93	240.04	178.60
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		10.59		7.14		15.97
CD (P=0.05)		24.42		16.47		32.58

### Interaction effect

The interaction effect between irrigation regimes and nitrogen levels on number of tillers/m<sup>2</sup> was found to be significant (Table 9, Table 10, Table 11, Table 12, Table 13 and Table 14) in all the three cuts during both the years. Application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha was found maximum number of tillers/m<sup>2</sup>. The lowest value were obtained in rainfed treatment in combined with 0 kg N/ha. With increased irrigation number and higher levels of nitrogen plant can greater use of available N which enhanced the uptake of nutrients resulting in more tillers due to more growth.

### Number of leaves/m<sup>2</sup>

Data on number of leaves/m<sup>2</sup> presented in Table 15 revealed that the effect of irrigation regimes was found to be significant in both the years. The highest number of leaves/m<sup>2</sup> was recorded with application of irrigation at IW:CPE ratio of 1.4 being of 697.63, 714.64, 704.07 and 702.44, 726.78, 711.88 which was found to be significantly higher than all other irrigation regimes at all the three cuts during both the years, respectively. This is due to more tillers/m<sup>2</sup>. The lowest value of number of leaves/m<sup>2</sup> were observed in rainfed treatment at 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> cut during both the years. The number of leaves/m<sup>2</sup> as influenced by different

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nitrogen levels was found to be significant in ryegrass during both the years are presented in Table 15. The number of leaves/m<sup>2</sup> increased with increasing levels of nitrogen and maximum number of leaves/m<sup>2</sup> were found with application of 90 kg N/ha being of 645.80, 670.68, 653.98 and 653.99, 683.51, 662.21 which was significantly higher than other lower levels of nitrogen at 1<sup>st</sup> cut, 2<sup>nd</sup> cut and 3<sup>rd</sup> cut, respectively in both the years. This might be due to the more tillers/m<sup>2</sup> under 90 kg N/ha resulting in cumulative effect on more number of leaves per unit area.

**Table 15. Effect of irrigation regimes (I) and nitrogen levels (N) on leaves/m<sup>2</sup> of ryegrass**

Treatments	Leaves/m <sup>2</sup>					
	1 <sup>st</sup> Year			2 <sup>nd</sup> Year		
	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut
<b>Irrigation regimes (I)</b>						
I <sub>0</sub>	344.25	363.63	350.46	352.39	371.63	362.56
I <sub>1</sub>	435.61	469.05	443.23	439.92	479.39	451.33
I <sub>2</sub>	510.66	527.84	516.92	517.02	542.80	524.14
I <sub>3</sub>	607.16	634.51	621.02	614.16	642.93	627.71
I <sub>4</sub>	697.63	714.64	704.07	702.44	726.78	711.88
S.Ed (±)	20.16	31.29	21.09	32.35	33.40	18.73
CD (P=0.05)	46.49	72.15	48.63	74.59	77.01	43.19
<b>Nitrogen levels (N)</b>						
N <sub>0</sub>	334.81	324.96	314.05	340.52	334.42	322.59
N <sub>1</sub>	530.30	555.40	538.14	535.50	565.82	546.57
N <sub>2</sub>	565.35	616.70	602.39	570.73	627.08	610.72
N <sub>3</sub>	645.80	670.68	653.98	653.99	683.51	662.21
S. Ed (±)	22.96	20.19	19.68	22.22	18.66	20.49
CD (P=0.05)	52.94	46.56	45.38	51.25	43.02	47.25
<b>Interaction (I×N)</b>						
S.Ed (±)	51.33	45.15	44.01	49.70	41.72	45.82
CD (P=0.05)	104.72	92.10	89.77	101.38	85.10	93.47
CV (%)	12.11	10.20	10.22	11.59	9.24	10.48

**Table 16. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on leaves/m<sup>2</sup> of ryegrass at 1<sup>st</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	

<b>N<sub>0</sub></b>	241.42	198.42	400.33	337.35	496.55	334.81
<b>N<sub>1</sub></b>	300.75	466.40	501.62	701.49	681.23	530.30
<b>N<sub>2</sub></b>	372.36	503.29	517.31	684.35	749.43	565.35
<b>N<sub>3</sub></b>	462.49	574.34	623.40	705.45	863.31	645.80
<b>Mean</b>	344.25	435.61	510.66	607.16	697.63	519.06
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		20.16		22.96		51.33
CD (P=0.05)		46.49		52.94		104.72

**Table 17. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on leaves/m<sup>2</sup> of ryegrass at 2<sup>nd</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	184.43	364.18	307.39	355.26	413.55	324.96
<b>N<sub>1</sub></b>	312.37	419.42	645.45	629.26	770.48	555.40
<b>N<sub>2</sub></b>	448.35	528.39	549.43	730.08	827.24	616.70
<b>N<sub>3</sub></b>	509.36	564.22	609.08	823.43	847.30	670.68
<b>Mean</b>	363.63	469.05	527.84	634.51	714.64	541.93
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		31.29		20.19		45.15
CD (P=0.05)		72.15		46.56		92.10

**Table 18. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on leaves/m<sup>2</sup> of ryegrass at 3<sup>rd</sup> cut (1<sup>st</sup> Year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	253.58	299.56	248.40	369.30	399.42	314.05
<b>N<sub>1</sub></b>	321.25	441.53	568.36	618.24	741.34	538.14
<b>N<sub>2</sub></b>	399.58	479.43	574.42	755.25	803.25	602.39
<b>N<sub>3</sub></b>	427.45	552.42	676.51	741.28	872.26	653.98

<b>Mean</b>	350.46	443.23	516.92	621.02	704.07	527.14
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		21.09		19.68		44.01
CD (P=0.05)		48.63		45.38		89.77

**Table 19. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on leaves/m<sup>2</sup> of ryegrass at 1<sup>st</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	246.57	203.10	406.98	344.89	501.06	340.52
N <sub>1</sub>	305.57	470.60	507.57	707.59	686.17	535.50
N <sub>2</sub>	377.40	507.44	523.43	691.23	754.16	570.73
N <sub>3</sub>	480.02	578.52	630.10	712.91	868.38	653.99
<b>Mean</b>	352.39	439.92	517.02	614.16	702.44	525.18
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		32.35		22.22		49.70
CD (P=0.05)		74.59		51.25		101.38

**Table 20. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on leaves/m<sup>2</sup> of ryegrass at 2<sup>nd</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	191.30	374.76	313.54	363.14	429.38	334.42
N <sub>1</sub>	320.83	429.62	652.17	636.70	789.75	565.82
N <sub>2</sub>	456.69	538.63	556.55	740.76	842.75	627.08
N <sub>3</sub>	517.71	574.56	648.96	831.11	845.22	683.51
<b>Mean</b>	371.63	479.39	542.80	642.93	726.78	552.71
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		33.40		18.66		41.72
CD (P=0.05)		77.01		43.02		85.10

**Table 21. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on leaves/m<sup>2</sup> of ryegrass at 3<sup>rd</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	265.27	307.62	256.00	375.79	408.28	322.59
N <sub>1</sub>	333.90	449.56	575.44	624.87	749.06	546.57
N <sub>2</sub>	411.50	487.53	581.49	762.15	810.91	610.72
N <sub>3</sub>	439.58	560.60	683.61	748.03	879.26	662.21
<b>Mean</b>	362.56	451.33	524.14	627.71	711.88	535.52
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		18.73		20.49		45.82
CD (P=0.05)		43.19		47.25		93.47

### Interaction effect

The interaction effect between irrigation regimes and nitrogen levels was found to differ significantly at all three cuts during both the years are presented in Table 16, Table 17, Table 18, Table 19, Table 20 and Table 21. The maximum number of leaves/m<sup>2</sup> were recorded with the application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha at 1<sup>st</sup> cut, 2<sup>nd</sup> cut and 3<sup>rd</sup> cut during both the years. The higher irrigation regime and nitrogen levels resulted in higher leaves/m<sup>2</sup> due to more tiller/m<sup>2</sup>.

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### Green fodder yield

Data on green fodder yield of ryegrass as influenced by different irrigation levels are presented in Table 22. Significantly the highest green fodder yield (392.03 q/ha and 391.27 q/ha, respectively in both the years) were recorded under irrigation at IW: CPE ratio of 1.4 over rest of the treatments. Thus the green fodder yield increased with the increasing levels of irrigation from IW:CPE ratio 1.0 to IW:CPE ratio 1.4 and all were being proved superior to rainfed in both the years. The increasing levels of irrigation increased the green fodder yield which is linked with higher performance of growth parameters. Jat *et al.*[6] and Meena *et al.*[26] found similar type of findings in their study. Favourable moisture status in soil resulted in good edaphic environment for availability of nutrients for plant growth. The effect of nitrogen levels on green fodder yield of ryegrass was found to be significant at all the three cuts during both the years (Table 22). Application of 90 kg N/ha recorded the highest green fodder yield (361.88 q/ha and 351.92 q/ha, respectively in both the years) which was significantly higher than all other levels of nitrogen. The lowest value were recorded in 0 kg N/ha. Application of higher dose of nitrogen increased the overall performance of growth parameters. Such improvement in various growth parameters directly influenced the fodder

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production. This was also in conformity with the findings of Agrawal *et al.*[27], Jat *et al.*[28] and Satpal *et al.* [29].

**Table 22. Effect of irrigation regimes (I) and nitrogen levels (N) on green fodder yield (q/ha) of ryegrass**

Treatments	Green fodder yield (q/ha)							
	1 <sup>st</sup> Year				2 <sup>nd</sup> Year			
	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	Total	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	Total
<b>Irrigation regimes (I)</b>								
I <sub>0</sub>	55.68	66.15	59.15	180.97	55.34	66.57	59.33	181.34
I <sub>1</sub>	76.72	87.54	80.13	240.11	78.50	87.84	82.50	248.56
I <sub>2</sub>	84.43	95.08	87.42	258.59	84.23	95.64	87.93	261.12
I <sub>3</sub>	99.70	110.63	105.89	316.22	100.03	111.09	106.10	317.22
I <sub>4</sub>	122.67	137.77	129.92	392.03	122.82	138.18	130.28	391.27
S.Ed (±)	4.26	5.40	8.29	7.11	3.94	6.41	7.98	17.13
CD (P=0.05)	9.83	12.45	19.11	16.40	9.09	14.78	18.41	39.51
<b>Nitrogen levels (N)</b>								
N <sub>0</sub>	47.29	62.29	56.36	163.86	54.30	62.97	57.08	174.12
N <sub>1</sub>	86.16	99.47	92.30	271.27	86.63	99.89	92.74	279.25
N <sub>2</sub>	98.71	110.53	104.10	313.34	98.93	110.74	104.64	314.31
N <sub>3</sub>	119.20	125.45	117.23	361.88	112.87	125.84	118.45	351.92
S. Ed (±)	2.56	2.99	3.05	8.37	2.45	2.91	3.03	8.75
CD (P=0.05)	5.90	6.90	7.02	19.31	5.64	6.70	7.00	20.18
<b>Interaction (I×N)</b>								
S.Ed (±)	5.72	6.69	6.81	18.72	5.47	6.50	6.78	19.57
CD (P=0.05)	11.68	13.65	13.89	38.19	11.16	13.26	13.84	39.92
CV (%)	7.98	8.24	9.02	8.26	7.60	7.97	8.91	8.56

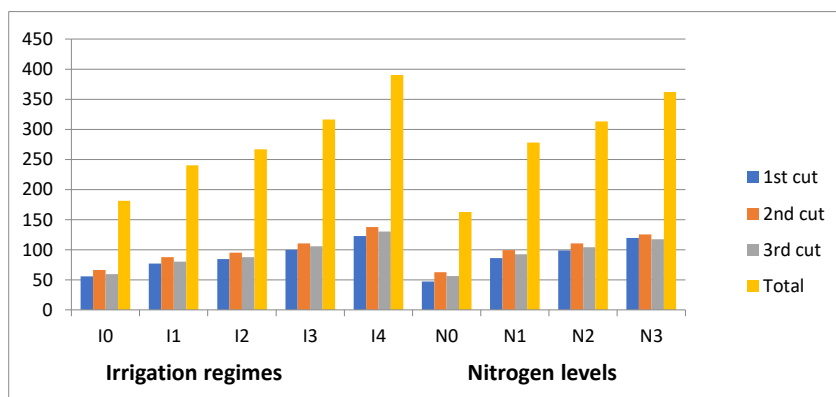


Fig. 1: Indicating the effect of irrigation regimes and nitrogen levels on green fodder yield (q/ha) of ryegrass (1<sup>st</sup> year)

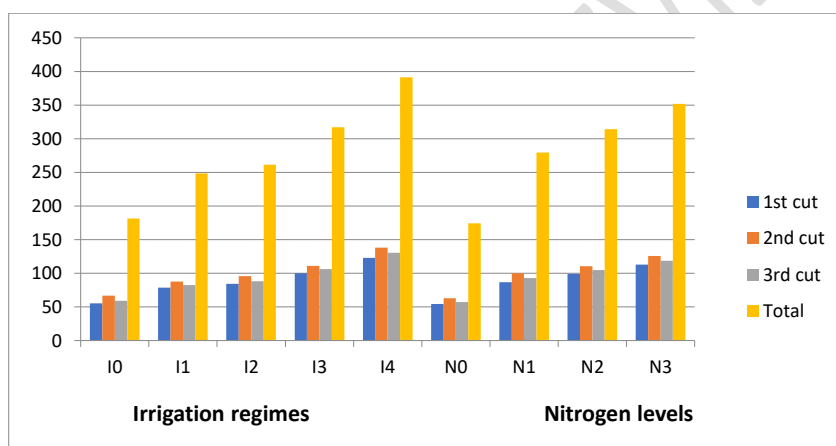


Fig. 2: Indicating the effect of irrigation regimes and nitrogen levels on green fodder yield (q/ha) of ryegrass (2<sup>nd</sup> year)

Table 23. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on green fodder yield (q/ha) of ryegrass at 1<sup>st</sup> cut (1<sup>st</sup> year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
No	27.36	39.19	45.16	52.77	71.98	47.29

<b>N<sub>1</sub></b>	51.32	75.15	82.47	97.89	123.96	86.16
<b>N<sub>2</sub></b>	63.39	85.22	95.67	112.42	136.83	98.71
<b>N<sub>3</sub></b>	80.66	107.30	114.41	135.72	157.91	119.20
<b>Mean</b>	55.68	76.72	84.43	99.70	122.67	87.84
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		4.26		2.56		5.72
CD (P=0.05)		9.83		5.90		11.68

**Table 24. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on green fodder yield (q/ha) of ryegrass at 2<sup>nd</sup> cut (1<sup>st</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	42.11	53.81	61.22	66.73	87.60	62.29
<b>N<sub>1</sub></b>	61.45	87.57	94.59	110.62	143.11	99.47
<b>N<sub>2</sub></b>	76.50	97.20	104.83	123.76	150.37	110.53
<b>N<sub>3</sub></b>	84.53	111.60	119.70	141.41	170.02	125.45
<b>Mean</b>	66.15	87.54	95.08	110.63	137.77	99.44
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		5.40		2.99		6.69
CD (P=0.05)		12.45		6.90		13.65

**Table 25. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on green fodder yield (q/ha) of ryegrass at 3<sup>rd</sup> cut (1<sup>st</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	35.18	48.14	57.17	61.73	79.60	56.36
<b>N<sub>1</sub></b>	54.76	81.57	85.78	105.62	133.78	92.30
<b>N<sub>2</sub></b>	69.08	91.20	96.19	119.76	144.30	104.10
<b>N<sub>3</sub></b>	77.58	99.60	110.53	136.44	162.02	117.23
<b>Mean</b>	59.15	80.13	87.42	105.89	129.92	92.50
		<b>I</b>		<b>N</b>		<b>I×N</b>

S.Ed ( $\pm$ )		8.29		3.05		6.81
CD (P=0.05)		19.11		7.02		13.89

**Table 26. Interaction effect of irrigation regimes (I)  $\times$  nitrogen levels (N) on total green fodder yield (q/ha) of ryegrass (1<sup>st</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	104.65	124.03	163.55	181.23	245.84	163.86
N <sub>1</sub>	167.53	244.30	229.50	314.14	400.85	271.27
N <sub>2</sub>	208.96	273.61	296.67	355.93	431.50	313.34
N <sub>3</sub>	242.77	318.49	344.63	413.58	489.95	361.88
<b>Mean</b>	180.98	240.11	258.59	316.22	392.03	277.59
		<b>I</b>		<b>N</b>		<b>I<math>\times</math>N</b>
S.Ed ( $\pm$ )		7.11		8.37		18.72
CD (P=0.05)		16.40		19.31		38.19

**Table 27. Interaction effect of irrigation regimes (I)  $\times$  nitrogen levels (N) on green fodder yield (q/ha) of ryegrass at 1<sup>st</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	33.29	47.42	52.47	59.61	78.70	54.30
N <sub>1</sub>	51.16	77.14	82.65	98.06	124.13	86.63
N <sub>2</sub>	63.05	87.00	94.37	113.27	136.96	98.93
N <sub>3</sub>	73.84	102.43	107.41	129.19	151.49	112.87
<b>Mean</b>	55.34	78.50	84.23	100.03	122.82	88.18
		<b>I</b>		<b>N</b>		<b>I<math>\times</math>N</b>
S.Ed ( $\pm$ )		3.94		2.45		5.47
CD (P=0.05)		9.09		5.64		11.16

**Table 28. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on green fodder yield (q/ha) of ryegrass at 2<sup>nd</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	43.08	54.26	62.19	67.66	87.65	62.97
N <sub>1</sub>	61.90	88.00	94.98	110.82	143.76	99.89
N <sub>2</sub>	76.56	97.39	105.15	123.95	150.67	110.74
N <sub>3</sub>	84.72	111.70	120.22	141.94	170.62	125.84
<b>Mean</b>	66.57	87.84	95.64	111.09	138.18	99.86
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		6.41		2.91		6.50
CD (P=0.05)		14.78		6.70		13.26

**Table 29. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on green fodder yield (q/ha) of ryegrass at 3<sup>rd</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	35.34	49.70	58.04	62.30	80.03	57.08
N <sub>1</sub>	54.84	83.00	86.08	105.69	134.08	92.74
N <sub>2</sub>	69.35	92.95	96.48	119.86	144.55	104.64
N <sub>3</sub>	77.80	104.35	111.12	136.54	162.46	118.45
<b>Mean</b>	59.33	82.50	87.93	106.10	130.28	93.23
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		7.98		3.03		6.78
CD (P=0.05)		18.41		7.00		13.84

**Table 30. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on total green fodder yield (q/ha) of ryegrass (2<sup>nd</sup> year)**

Nitrogen	Irrigation regimes (I)	Mean
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levels (N)	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	111.71	150.28	172.69	189.56	246.38	174.12
N <sub>1</sub>	167.89	248.14	263.71	314.57	401.97	279.25
N <sub>2</sub>	208.97	277.34	296.00	357.08	432.18	314.31
N <sub>3</sub>	236.77	318.48	312.09	407.67	484.57	351.92
Mean	181.34	248.56	261.12	317.22	391.27	279.90
		I		N		I×N
S.Ed (±)		17.13		8.75		19.57
CD (P=0.05)		39.51		20.18		39.92

### Interaction effect

The interaction effect of irrigation regimes and nitrogen levels was found to be statistically significant in respect of green fodder yield (Table 23, Table 24, Table 25, Table 26, Table 27, Table 28, Table 29 and Table 30) in all the three cuts during both the years. The highest green fodder yield were recorded with the application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha at 1<sup>st</sup> cut, 2<sup>nd</sup> cut, 3<sup>rd</sup> cut followed by irrigation at IW:CPE ratio of 1.2 in combination with 60 kg N/ha. The lowest green fodder yield were recorded in rainfed treatment in combination with 0 kg N/ha during both the years. Due to beneficial effect of irrigation regimes and nitrogen levels, the highest green fodder yield was obtained in irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha.

Commented [I19]: significant with respect to green

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### Dry matter content

During both the years, different irrigation regimes and nitrogen levels did not bring about any significant effect on the dry matter content (Table 31) of ryegrass.

**Table 31. Effect of irrigation regimes (I) and nitrogen levels (N) on dry matter content (%) of ryegrass**

Treatments	Dry matter content (%)					
	1 <sup>st</sup> Year			2 <sup>nd</sup> Year		
	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut
<b>Irrigation regimes (I)</b>						
I <sub>0</sub>	18.33	18.86	18.43	18.59	19.15	18.61
I <sub>1</sub>	18.45	19.35	18.68	18.62	19.59	18.74
I <sub>2</sub>	18.63	19.63	19.26	18.82	19.78	19.21
I <sub>3</sub>	19.31	20.17	19.29	19.44	20.40	19.53
I <sub>4</sub>	19.48	20.22	19.65	19.57	20.54	19.57

S.Ed ( $\pm$ )	1.16	1.11	1.16	0.90	0.72	0.81
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<b>Nitrogen levels (N)</b>						
N <sub>0</sub>	18.54	19.35	18.84	18.74	19.52	19.10
N <sub>1</sub>	18.75	19.48	18.63	19.03	19.90	18.61
N <sub>2</sub>	18.88	19.62	19.34	19.14	19.82	19.25
N <sub>3</sub>	19.18	20.14	19.44	19.13	20.32	19.57
S. Ed ( $\pm$ )	0.67	0.64	0.70	0.71	0.62	0.66
CD (P=0.05)	NS	NS	NS	NS	NS	NS
<b>Interaction (I×N)</b>						
S.Ed ( $\pm$ )	1.50	1.43	1.56	1.60	1.38	1.48
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	9.77	8.89	10.05	10.28	8.47	9.50

N.S: Non-significant

### Dry matter yield

The effect of different levels of irrigation on dry matter yield of the ryegrass was found to be significant in all the three cuts in both the years (Table 32). Results revealed that the dry matter yield increased during both the years with increasing levels of irrigation from IW:CPE ratio of 1.0 to IW: CPE ratio of 1.4. Significantly higher values of dry matter yield (85.33 q/ha and 79.44 q/ha, respectively in both the years) produced over that of rainfed and critical growth stages. Thus, the highest dry matter yield was recorded under irrigation at IW:CPE ratio of 1.4 and the lowest was under rainfed condition in both the years. Water stress depressed the vegetative growth and dry matter accumulation. Because it led to adversely affect cell division and enlargement of different plant tissues. These findings are in agreement with Hussein and Sabbour [30]. The effect of nitrogen levels was found to be statistically significant in respect of dry matter yield of ryegrass in all the three cuts during both the years are presented in Table 32. Significantly higher dry matter yield (72.86 q/ha and 71.46 q/ha, respectively in both the years) were found with the application of 90 kg N/ha compared to other lower nitrogen levels. The lowest value of dry matter yield were observed in 0 kg N/ha. This might be due to application of higher levels of nitrogen which ensured cell division, cell enlargement and increased photosynthetic area. This increased photosynthetic area was able to utilize more radiation which ultimately increased photosynthetic production reflected on yield. Jehangir *et al.* [21] also reported that increase in fertility level upto 150 kg N ha<sup>-1</sup> increased both green and dry fodder yields. The abundant supply of nitrogen may have increased protoplasmic constituents and accelerated the process of cell division and

Commented [121]: were produced

Commented [122]: up to

elongation, which has resulted in luxuriant vegetative growth in terms of plant height, thereby, higher biomass and dry matter yield [31].

**Table 32. Effect of irrigation regimes (I) and nitrogen levels (N) on dry matter yield (q/ha) of ryegrass**

Treatments	Dry matter yield (q/ha)							
	1 <sup>st</sup> Year				2 <sup>nd</sup> Year			
	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	Total	1 <sup>st</sup> cut	2 <sup>nd</sup> cut	3 <sup>rd</sup> cut	Total
<b>Irrigation regimes (I)</b>								
I <sub>0</sub>	10.09	12.43	10.87	33.39	10.18	12.74	11.00	33.95
I <sub>1</sub>	14.25	17.04	14.98	46.26	14.80	17.27	15.52	47.59
I <sub>2</sub>	15.90	18.95	17.09	52.35	15.91	19.05	17.23	51.44
I <sub>3</sub>	18.52	22.53	20.69	61.74	19.76	22.94	20.91	63.59
I <sub>4</sub>	24.94	30.61	28.95	85.33	24.77	28.44	26.91	79.44
S.Ed (±)	1.61	0.88	0.68	3.67	0.96	1.31	0.94	2.29
CD (P=0.05)	3.72	2.04	1.56	8.46	2.21	3.01	2.18	5.28
<b>Nitrogen levels (N)</b>								
N <sub>0</sub>	8.77	12.66	11.27	33.37	10.26	12.39	11.31	33.83
N <sub>1</sub>	16.33	20.14	17.98	54.78	16.70	19.99	17.61	53.85
N <sub>2</sub>	18.75	22.45	21.05	62.25	19.03	22.21	20.43	61.66
N <sub>3</sub>	23.10	26.00	23.76	72.86	22.35	25.75	23.90	71.46
S. Ed (±)	0.65	0.77	0.76	2.13	0.74	0.80	0.84	2.12
CD (P=0.05)	1.51	1.77	1.75	4.92	1.71	1.83	1.94	4.89
<b>Interaction (I×N)</b>								
S.Ed (±)	1.46	1.72	1.70	4.77	1.66	1.78	1.88	4.74
CD (P=0.05)	2.98	3.51	3.47	9.73	3.38	3.63	3.84	9.67
CV (%)	10.68	10.37	11.24	10.47	11.87	10.84	12.59	10.52

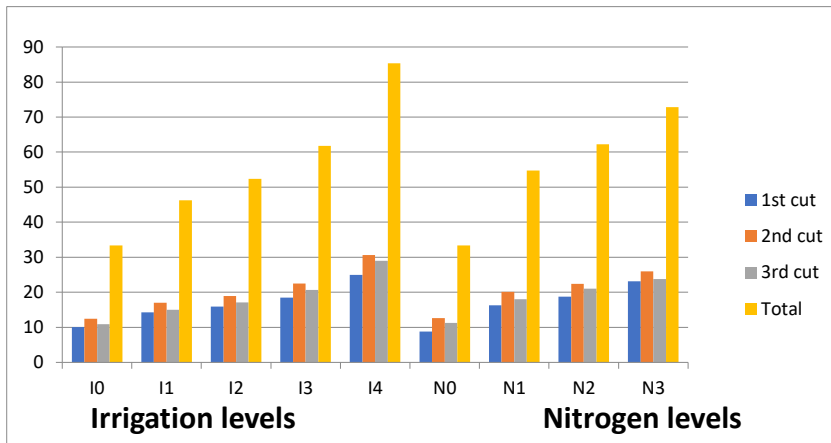


Fig 3: Indicating the effect of irrigation regimes and nitrogen levels on dry matter yield (q/ha) of ryegrass (1<sup>st</sup> year)

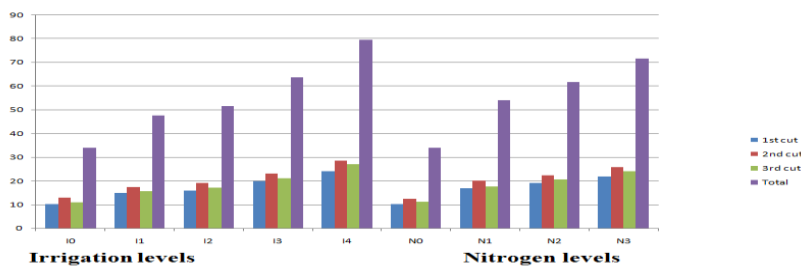


Fig 4: Indicating the effect of irrigation regimes and nitrogen levels on dry matter yield (q/ha) of ryegrass (2<sup>nd</sup> year)

Table 33. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on dry matter yield (q/ha) of ryegrass at 1<sup>st</sup> cut (1<sup>st</sup> year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	5.33	7.1	8.24	8.05	15.14	8.77
N <sub>1</sub>	8.99	13.55	16.22	18.28	24.61	16.33
N <sub>2</sub>	12.03	15.49	16.93	21.43	27.89	18.75
N <sub>3</sub>	14.01	20.84	22.21	26.32	32.11	23.10
Mean	10.09	14.25	15.90	18.52	24.94	16.74

		I		N		I×N
S.Ed (±)		1.61		0.65		1.46
CD (P=0.05)		3.72		1.51		2.98

**Table 34. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on dry matter yield (q/ha) of ryegrass at 2<sup>nd</sup> cut (1<sup>st</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	8.23	10.25	11.82	11.98	21.01	12.66
N <sub>1</sub>	11.34	16.47	19.93	22.94	30.00	20.14
N <sub>2</sub>	14.45	18.73	19.74	25.55	33.79	22.45
N <sub>3</sub>	15.70	22.70	24.33	29.64	37.65	26.00
<b>Mean</b>	12.43	17.04	18.95	22.53	30.61	20.31
		I		N		I×N
S.Ed (±)		0.88		0.77		1.72
CD (P=0.05)		2.04		1.77		3.51

**Table 35. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on dry matter yield (q/ha) of ryegrass at 3<sup>rd</sup> cut (1<sup>st</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	6.70	9.06	11.10	10.65	18.86	11.27
N <sub>1</sub>	9.72	15.12	16.87	20.79	27.38	17.98
N <sub>2</sub>	13.59	16.51	18.04	23.68	33.42	21.05
N <sub>3</sub>	13.49	19.22	22.32	27.65	36.13	23.76
<b>Mean</b>	10.87	14.98	17.09	20.69	28.95	18.52
		I		N		I×N
S.Ed (±)		0.68		0.76		1.70
CD (P=0.05)		1.56		1.75		3.47

**Table 36. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on total dry matter yield (q/ha) of ryegrass (1<sup>st</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	20.26	26.41	31.16	30.68	58.35	33.37
N <sub>1</sub>	30.05	45.14	54.68	62.02	81.99	54.78
N <sub>2</sub>	40.06	50.74	54.71	70.66	95.10	62.25
N <sub>3</sub>	43.20	62.77	68.87	83.61	105.88	72.86
Mean	33.39	46.26	52.35	61.74	85.33	55.82
		I		N		I×N
S.Ed (±)		3.67		2.13		4.77
CD (P=0.05)		8.46		4.92		9.73

**Table 37. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on dry matter yield (q/ha) of ryegrass at 1<sup>st</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	6.43	8.77	9.89	10.41	15.79	10.26
N <sub>1</sub>	9.27	14.36	16.36	19.57	23.92	16.70
N <sub>2</sub>	12.05	16.58	16.78	22.82	26.92	19.03
N <sub>3</sub>	12.97	19.51	20.62	26.23	32.43	22.35
Mean	10.18	14.80	15.91	19.76	24.77	17.08
		I		N		I×N
S.Ed (±)		0.96		0.74		1.66
CD (P=0.05)		2.21		1.71		3.38

**Table 38. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on dry matter yield (q/ha) of ryegrass at 2<sup>nd</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
N <sub>0</sub>	8.49	10.52	12.02	12.28	18.66	12.39

<b>N<sub>1</sub></b>	11.72	17.13	19.90	23.24	27.97	19.99
<b>N<sub>2</sub></b>	14.81	18.78	19.86	25.90	31.68	22.21
<b>N<sub>3</sub></b>	15.95	22.64	24.41	30.32	35.44	25.75
<b>Mean</b>	12.74	17.27	19.05	22.94	28.44	20.09
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		1.31		0.80		1.78
CD (P=0.05)		3.01		1.83		3.63

**Table 39. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on dry matter yield (q/ha) of ryegrass at 3<sup>rd</sup> cut (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	6.78	9.40	12.04	11.32	17.00	11.31
<b>N<sub>1</sub></b>	9.79	15.39	16.60	21.06	25.22	17.61
<b>N<sub>2</sub></b>	13.72	16.95	18.07	23.46	29.94	20.43
<b>N<sub>3</sub></b>	13.72	20.34	22.20	27.80	35.46	23.90
<b>Mean</b>	11.00	15.52	17.23	20.91	26.91	18.31
		<b>I</b>		<b>N</b>		<b>I×N</b>
S.Ed (±)		0.94		0.84		1.88
CD (P=0.05)		2.18		1.94		3.84

**Table 40. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on total dry matter yield (q/ha) of ryegrass (2<sup>nd</sup> year)**

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I <sub>0</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	
<b>N<sub>0</sub></b>	21.71	28.69	33.29	34.01	51.46	33.83
<b>N<sub>1</sub></b>	30.88	46.87	50.53	63.87	77.11	53.85
<b>N<sub>2</sub></b>	40.58	52.31	54.72	72.19	88.53	61.66
<b>N<sub>3</sub></b>	42.64	62.48	67.23	84.30	100.67	71.46
<b>Mean</b>	33.95	47.59	51.44	63.59	79.44	55.20
		<b>I</b>		<b>N</b>		<b>I×N</b>

S.Ed ( $\pm$ )		2.29		2.12		4.74
CD (P=0.05)		5.28		4.89		9.67

### Interaction effect

The interaction effect between irrigation regimes and nitrogen levels was found to differ significantly at all three cuts during both the years (Table 33, Table 34, Table 35, Table 36, Table 37, Table 38, Table 39 and Table 40). The application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha recorded the highest dry matter yield at 1<sup>st</sup> cut, 2<sup>nd</sup> cut and 3<sup>rd</sup> cut during both the years followed by irrigation at IW:CPE ratio of 1.2 in combination with 60 kg N/ha. Rainfed treatment in combination with 0 kg N/ha recorded the lowest dry matter yield in all three cuts during both the years. The irrigation and nitrogen both had positive effect on dry matter yield. The highest dry matter yield was found in the treatment receiving irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha due to favourable conditions of having more irrigation and N fertilization.

Commented [I23]: significantly

Commented [I24]: a positive

### 4. CONCLUSION

The result obtained from the experiment revealed that ryegrass significantly responded to increased nitrogen levels and irrigation at IW: CPE ratio of 1.4 showing positive effect on all the growth and yield parameters. The maximum plant height recorded in irrigation at IW:CPE ratio of 1.4 which was significant to other irrigation regimes. Significantly, maximum number of tiller/m<sup>2</sup> and number of leaves/m<sup>2</sup> were observed in irrigation at IW:CPE ratio of 1.4 followed by irrigation at IW:CPE ratio of 1.2. Irrigation at IW:CPE ratio of 1.4 recorded the highest green fodder yield and dry matter yield which was significant to other irrigation treatments. However, no significant difference has been found in case of dry matter content. Application of 90 kg N/ha recorded the significantly higher plant height, number of tillers/m<sup>2</sup> and number of leaves/m<sup>2</sup> among the other nitrogen treatment. Significantly higher green fodder yield and dry matter yield were obtained with application of 90 kg N/ha followed by 60 kg N/ha. But dry matter content remained unaffected due to different nitrogen treatments. The higher plant height, tillers/m<sup>2</sup> and number of leaves/m<sup>2</sup> were recorded with the application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha during both the years. Among the different treatment combination of irrigation regimes and nitrogen levels, the highest green fodder yield and dry matter yield were recorded with application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha.

Commented [I25]: treatments

Commented [I26]: combinations

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