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Growth and Yield Parameters of Ryegrass (*Lolium multiflorum*) as Influenced by Irrigation Regimes and Nitrogen Levels

Nilotpal Hazarika [a*], Karuna Kanta Sharma [b++], Khagen Kurmi [a#] and Bipul Deka [c#]

[a] *Department of Agronomy, Assam Agricultural University, Jorhat-785013, Assam, India.*
[b] *Advanced Centre for IFS Research, Assam Agricultural University, Jorhat-785013, Assam, India.*
[c] *Department of Soil Science, Assam Agricultural University, Jorhat-785013, Assam, India.*

Authors' contributions

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

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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_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 -

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

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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, acidic in reaction, medium in organic carbon, medium in available N, available P_2O_5 and low in available K_2O. The results revealed that different irrigation regimes significantly influenced the plant height, number of tillers/m^2, number of leaves/m^2, 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^2, number of leaves/m^2, 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.

Keywords: Ryegrass; IW:CPE ratio; N levels; green fodder yield; dry matter yied.

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 [1-4]. 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. Keeping all these in view, the investigation was undertaken to study the forage productivity of ryegrass under different irrigation regimes and nitrogen levels.

Gangaiah [5] 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 [6]. Mitra et al. [7] observed that irrigation at 20 mm CPE significantly recorded the maximum plant height and total no. of tillers m^{-1} 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 [8]. Hussein et al. [9] found that growth and yield of sorghum cultivated for forage or for seeds increased with increasing soil moisture. Jat et al. [10] reported that five irrigations (20, 40, 60, 80 and 100 DAS) gave 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. [11] 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. [12] found that irrigation at IW:CPE of 1.1 recorded higher green fodder, dry matter and crude protein yield of oats. Patel et al. [13] 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. [14] and Lippke et al. [15] 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 [16] reported that increase in levels of N application increased plant height in fodder maize. Increasing levels of nitrogen upto 160 kg ha^{-1} improved the plant height and number of tillers of oats [17]. Application of nitrogen significantly increased the growth and yields of fodder oat. Application of 100 kg N ha^{-1} 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^{-1} with respect to plant height but significantly superior to rest of levels [18]. Godara et al. [19] reported that increasing levels of nitrogen from 40 to 120 kg ha^{-1} 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^{-1} . Hasan et al. [20] 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. [21] found higher fodder yield of maizewith increase in nitrogen level up to 150 kg/ha. Rawat and Agrawal [18] reported that application of 100 kg N ha^{-1} recorded maximum green fodder yield (361.5 q ha^{-1}) and dry matter yield (100.2 q ha^{-1}) of fodder oat which was at par with 80 kg N ha^{-1} but significantly superior to rest of the levels.Application of 240 kg N ha^{-1} recorded significantly higher green fodder yield, dry matter yield and crude protein of maize [22]. Pradhan et al. [23] 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. [24] 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^{-1} increased green and dry fodder yields of oat [25]. Mahdi et al. [26] 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^{-1} (8709 and 9624 kg ha^{-1}) during both first and second cuttings [27].

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 amount of irrigation water was measured as follows:

$$q = a \times d$$

Where,

q = quantity of water needed for each irrigation (m^3)
a = area to be irrigated (plot size-18 m^2)
d = depth of water (6 cm)

So, irrigation water applied in each irrigation to-

$$q = 18\ m^2 \times 0.06\ m = 1.08\ m^3\ plot^{-1}$$
$$= 1080\ litre\ plot^{-1}$$

Average discharge rate of the pump = 3.5 l/sec

Therefore, time required to irrigate an individual plot was,

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

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

3.1 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 1st cut, 2nd cut and 3rd 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 [5] is in conformity with the present findings. The effete 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_3) at 1st cut, 2nd cut and 3rd cut during both the years, respectively which was significantly higher than other N levels i.e. 60 kg N/ha (N_2), 30 kg N/ha (N_2) and 0 kg N/ha (N_0). The lowest value was found in N_0 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 [17] 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)					
	1st Year			2nd Year		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Irrigation regimes (I)						
I_0	25.94	36.43	26.95	26.30	37.16	27.29
I_1	32.23	42.66	39.67	32.66	43.62	40.31
I_2	36.90	47.68	41.33	37.18	47.87	43.19
I_3	39.55	50.93	48.65	39.88	53.08	50.41
I_4	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
Nitrogen levels (N)						
N_0	23.22	29.05	29.07	23.38	29.56	30.26
N_1	35.22	48.59	42.18	35.28	50.54	43.15
N_2	39.35	53.37	46.33	39.63	54.74	47.41
N_3	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
Interaction (I×N)						
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 1st cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	18.60	16.83	25.33	26.20	29.13	23.22
N_1	25.43	32.27	35.13	41.27	42.00	35.22
N_2	28.73	39.03	37.87	41.20	49.93	39.35
N_3	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 2nd cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	20.05	24.73	31.62	34.29	34.53	29.05
N_1	38.23	44.66	48.60	51.09	60.35	48.59
N_2	40.32	48.53	54.14	58.67	65.22	53.37
N_3	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 3rd cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	17.10	27.67	28.90	35.00	36.67	29.07
N_1	25.71	41.40	42.07	47.33	54.40	42.18
N_2	28.37	42.80	43.98	54.97	61.53	46.33
N_3	36.63	46.80	50.36	57.30	67.31	51.68
Mean	26.95	39.67	41.33	48.65	54.98	42.32
		I		**N**		**I×N**
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 1st cut (2nd Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	18.83	17.33	25.83	26.83	28.07	23.38
N_1	26.15	32.74	35.37	40.93	41.23	35.28
N_2	29.09	39.61	38.13	41.63	49.70	39.63
N_3	31.15	40.94	49.40	50.13	55.14	45.35
Mean	26.30	32.66	37.18	39.88	43.54	35.91
		I		**N**		**I×N**
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 2nd cut (2nd Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	20.60	25.73	31.05	35.54	34.87	29.56
N_1	40.12	46.31	49.69	53.33	63.26	50.54
N_2	40.47	49.09	54.21	62.56	67.40	54.74
N_3	47.43	53.34	56.54	60.89	73.11	58.26
Mean	37.16	43.62	47.87	53.08	59.66	48.28
		I		**N**		**I×N**
S.Ed (±)		1.97		1.18		2.65
CD (P=0.05)		4.54		2.73		5.40

Table 7. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on plant height (cm) of ryegrass at 3rd cut (2nd Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	17.37	28.86	30.81	36.59	37.67	30.26
N_1	25.90	41.84	43.95	49.24	54.80	43.15
N_2	28.78	43.49	45.85	56.73	62.22	47.41
N_3	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

3.2 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 1st cut, 2nd cut and 3rd 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 [28]. The lowest value on plant height were recorded in rainfed treatment combined with 0 kg N/ha.

3.3 Number of Tillers/m^2

The effect of different levels of irrigation on number of tillers/m^2 of ryegrass was found to be significant during both the years (Table 8). Significantly highest numbers of tiller/m^2 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^2 increased with increasing levels of irrigation from IW:CPE ratio 1.0 to IW:CPE ratio1.4. 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. [10] also reported similar findings.Different nitrogen levels significantly influenced the number of tillers/m^2 of ryegrass in both the years (Table 8). The increased number of tillers/m^2 were found with increasing levels of nitrogen. The highest number of tillers/m^2 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^2 over 0 kg N/ha at 1st cut, 2nd cut and 3rd 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 Woledgeand Pearse [29]. Jat et al. [10] found that application of 110 kg N ha^{-1} gave significantly higher number of tillers m^{-1} row lengthover 70 kg N ha^{-1} but statistically at par with rest of treatment (90 kg N/ha). The improvement innutritional status of plant might have resultedin greater synthesis of amino

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

Treatments	Tillers/m^2					
	1st Year			2nd Year		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Irrigation regimes (I)						
I_0	114.93	121.45	117.33	115.38	124.89	117.56
I_1	149.25	151.64	148.43	146.82	157.79	151.91
I_2	170.46	179.02	172.54	174.86	183.17	173.55
I_3	188.56	201.98	207.18	203.32	212.39	209.93
I_4	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
Nitrogen levels (N)						
N_0	109.07	107.01	104.83	112.83	111.11	107.50
N_1	174.23	180.01	179.76	178.13	188.02	182.25
N_2	188.85	203.66	201.50	189.98	208.45	203.85
N_3	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
Interaction (I×N)						
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

acids,proteins and other growth promoting substances which seems to have enhanced the meristematicactivity and increased cell division and enlargement and their elongation resulted in more number of tillers.

Table 9. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on tillers/m^2 of ryegrass at 1st cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	80.57	66.35	133.60	98.73	166.10	109.07
N_1	100.25	155.88	167.44	220.01	227.58	174.23
N_2	124.40	182.92	172.64	214.29	250.00	188.85
N_3	154.51	191.83	208.18	221.22	287.96	212.74
Mean	114.93	149.25	170.46	188.56	232.91	171.22
		I		**N**		**I×N**
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^2 of ryegrass at 2nd cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	61.57	121.61	102.77	108.60	140.50	107.01
N_1	104.63	120.00	215.20	199.93	260.29	180.01
N_2	149.73	176.39	183.51	232.61	276.04	203.66
N_3	169.86	188.55	214.59	266.77	281.06	224.16
Mean	121.45	151.64	179.02	201.98	239.47	178.71
		I		**N**		**I×N**
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^2 of ryegrass at 3rd cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	84.57	99.92	83.10	123.17	133.40	104.83
N_1	108.38	147.22	189.73	206.20	247.27	179.76
N_2	133.54	162.00	191.76	252.13	268.06	201.50
N_3	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^2 of ryegrass at 1st cut (2nd Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	80.68	67.64	135.81	113.30	166.74	112.83
N_1	100.76	157.05	169.66	234.35	228.84	178.13
N_2	125.25	169.33	175.21	228.85	251.29	189.98
N_3	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^2 of ryegrass at 2nd cut (2nd Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	65.07	122.81	106.81	119.05	141.80	111.11
N_1	107.84	141.16	219.54	210.39	261.18	188.02
N_2	153.05	177.39	187.40	245.15	279.26	208.45
N_3	173.59	189.81	218.93	275.00	281.45	227.76
Mean	124.89	157.79	183.17	212.39	240.92	183.83
		I		N		I×N
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^2 of ryegrass at 3rd cut (2nd Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	85.00	103.34	84.38	126.23	138.55	107.50
N_1	108.48	150.97	190.58	208.74	252.46	182.25
N_2	133.70	165.43	192.60	254.42	273.11	203.85
N_3	143.07	187.89	226.63	250.32	296.04	220.79
Mean	117.56	151.91	173.55	209.93	240.04	178.60
		I		N		I×N
S.Ed (±)		10.59		7.14		15.97
CD (P=0.05)		24.42		16.47		32.58

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

Treatments	Leaves/m^2					
	1st Year			2nd Year		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Irrigation regimes (I)						
I_0	344.25	363.63	350.46	352.39	371.63	362.56
I_1	435.61	469.05	443.23	439.92	479.39	451.33
I_2	510.66	527.84	516.92	517.02	542.80	524.14
I_3	607.16	634.51	621.02	614.16	642.93	627.71
I_4	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
Nitrogen levels (N)						
N_0	334.81	324.96	314.05	340.52	334.42	322.59
N_1	530.30	555.40	538.14	535.50	565.82	546.57
N_2	565.35	616.70	602.39	570.73	627.08	610.72
N_3	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
Interaction (I×N)						
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/m² of ryegrass at 1st cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	241.42	198.42	400.33	337.35	496.55	334.81
N_1	300.75	466.40	501.62	701.49	681.23	530.30
N_2	372.36	503.29	517.31	684.35	749.43	565.35
N_3	462.49	574.34	623.40	705.45	863.31	645.80
Mean	344.25	435.61	510.66	607.16	697.63	519.06
		I		**N**		**I×N**
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/m² of ryegrass at 2nd cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	184.43	364.18	307.39	355.26	413.55	324.96
N_1	312.37	419.42	645.45	629.26	770.48	555.40
N_2	448.35	528.39	549.43	730.08	827.24	616.70
N_3	509.36	564.22	609.08	823.43	847.30	670.68
Mean	363.63	469.05	527.84	634.51	714.64	541.93
		I		**N**		**I×N**
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/m² of ryegrass at 3rd cut (1st Year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	253.58	299.56	248.40	369.30	399.42	314.05
N_1	321.25	441.53	568.36	618.24	741.34	538.14
N_2	399.58	479.43	574.42	755.25	803.25	602.39
N_3	427.45	552.42	676.51	741.28	872.26	653.98
Mean	350.46	443.23	516.92	621.02	704.07	527.14
		I		**N**		**I×N**
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/m² of ryegrass at 1st cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	246.57	203.10	406.98	344.89	501.06	340.52
N_1	305.57	470.60	507.57	707.59	686.17	535.50
N_2	377.40	507.44	523.43	691.23	754.16	570.73
N_3	480.02	578.52	630.10	712.91	868.38	653.99
Mean	352.39	439.92	517.02	614.16	702.44	525.18
		I		**N**		**I×N**
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/m² of ryegrass at 2nd cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	191.30	374.76	313.54	363.14	429.38	334.42
N_1	320.83	429.62	652.17	636.70	789.75	565.82
N_2	456.69	538.63	556.55	740.76	842.75	627.08
N_3	517.71	574.56	648.96	831.11	845.22	683.51
Mean	371.63	479.39	542.80	642.93	726.78	552.71
		I		**N**		**I×N**
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/m² of ryegrass at 3rd cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	265.27	307.62	256.00	375.79	408.28	322.59
N_1	333.90	449.56	575.44	624.87	749.06	546.57
N_2	411.50	487.53	581.49	762.15	810.91	610.72
N_3	439.58	560.60	683.61	748.03	879.26	662.21
Mean	362.56	451.33	524.14	627.71	711.88	535.52
		I		**N**		**I×N**
S.Ed (±)		18.73		20.49		45.82
CD (P=0.05)		43.19		47.25		93.47

3.4 Interaction Effect

The interaction effect between irrigation regimes and nitrogen levels on number of tillers/m² 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/m². 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.

3.5 Number of Leaves/m²

Data on number of leaves/m² 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/m² 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/m². The lowest value of number of leaves/m² were observed in rainfed treatment at 1st, 2nd and 3rd cut during both the years. The number of leaves/m² as influenced by different nitrogen levels was found to be significant in ryegrass during both the years are presented in Table 15. The number of leaves/m² increased with increasing levels of nitrogen and maximum number of leaves/m² 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 1st cut, 2nd cut and 3rd cut, respectively in both the years. This might be due to the more tillers/m² under 90 kg N/ha resulting in cumulative effect on more number of leaves per unit area.

3.6 Interaction Effect

The interaction effect between irrigation regimes and nitrogen levels was found to differ significant 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/m² were recorded with the application of irrigation at IW:CPE ratio of 1.4 in combination with 90 kg N/ha at 1st cut, 2nd cut and 3rd cut during both the years. The higher irrigation regime and nitrogen levels resulted in higher leaves/m² due to more tiller/m².

3.7 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. [10] and Meena et al. [30] 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 production. This was also in conformity with the findings of Agrawal et al. [31], Jat et al.[32] and Satpal et al. [33].

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)							
	1st Year				2nd Year			
	1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Total
Irrigation regimes (I)								
I_0	55.68	66.15	59.15	180.97	55.34	66.57	59.33	181.34
I_1	76.72	87.54	80.13	240.11	78.50	87.84	82.50	248.56
I_2	84.43	95.08	87.42	258.59	84.23	95.64	87.93	261.12
I_3	99.70	110.63	105.89	316.22	100.03	111.09	106.10	317.22
I_4	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
Nitrogen levels (N)								
N_0	47.29	62.29	56.36	163.86	54.30	62.97	57.08	174.12
N_1	86.16	99.47	92.30	271.27	86.63	99.89	92.74	279.25
N_2	98.71	110.53	104.10	313.34	98.93	110.74	104.64	314.31
N_3	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
Interaction (I×N)								
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

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

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	27.36	39.19	45.16	52.77	71.98	47.29
N_1	51.32	75.15	82.47	97.89	123.96	86.16
N_2	63.39	85.22	95.67	112.42	136.83	98.71
N_3	80.66	107.30	114.41	135.72	157.91	119.20
Mean	55.68	76.72	84.43	99.70	122.67	87.84
		I		N		I×N
S.Ed (±)		4.26		2.56		5.72
CD (P=0.05)		9.83		5.90		11.68

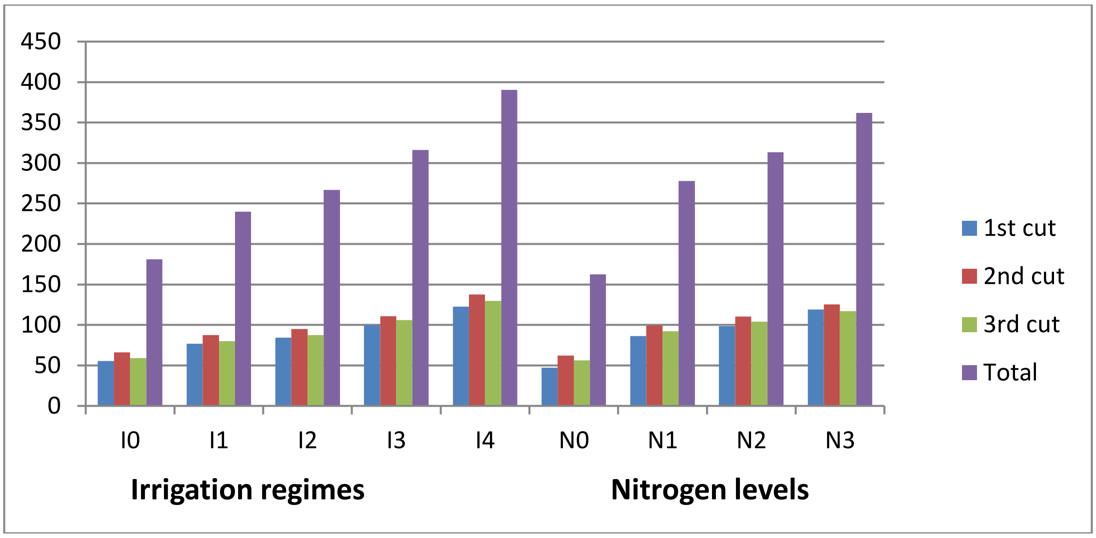

Fig. 1. Indicating the effect of irrigation regimes and nitrogen levels on green fodder yield (q/ha) of ryegrass (1st year)

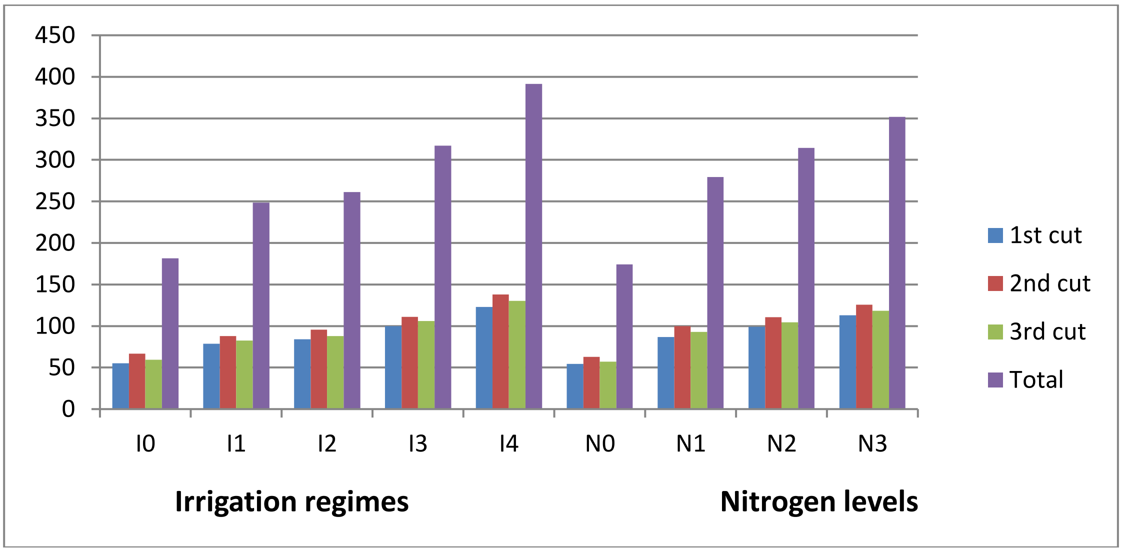

Fig. 2. Indicating the effect of irrigation regimes and nitrogen levels on green fodder yield (q/ha) of ryegrass (2nd year)

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

Nitrogen levels (N)	**Irrigation regimes (I)**					**Mean**
	I_0	**I_1**	**I_2**	**I_3**	**I_4**	
N_0	42.11	53.81	61.22	66.73	87.60	62.29
N_1	61.45	87.57	94.59	110.62	143.11	99.47
N_2	76.50	97.20	104.83	123.76	150.37	110.53
N_3	84.53	111.60	119.70	141.41	170.02	125.45
Mean	66.15	87.54	95.08	110.63	137.77	99.44
		I		**N**		**I×N**
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 3rd cut (1st year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	35.18	48.14	57.17	61.73	79.60	56.36
N_1	54.76	81.57	85.78	105.62	133.78	92.30
N_2	69.08	91.20	96.19	119.76	144.30	104.10
N_3	77.58	99.60	110.53	136.44	162.02	117.23
Mean	59.15	80.13	87.42	105.89	129.92	92.50
		I		**N**		**I×N**
S.Ed (±)		8.29		3.05		6.81
CD (P=0.05)		19.11		7.02		13.89

Table 26. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on total green fodder yield (q/ha) of ryegrass (1st year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	104.65	124.03	163.55	181.23	245.84	163.86
N_1	167.53	244.30	229.50	314.14	400.85	271.27
N_2	208.96	273.61	296.67	355.93	431.50	313.34
N_3	242.77	318.49	344.63	413.58	489.95	361.88
Mean	180.98	240.11	258.59	316.22	392.03	277.59
		I		**N**		**I×N**
S.Ed (±)		7.11		8.37		18.72
CD (P=0.05)		16.40		19.31		38.19

Table 27. Interaction effect of irrigation regimes (I) × nitrogen levels (N) on green fodder yield (q/ha) of ryegrass at 1st cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	33.29	47.42	52.47	59.61	78.70	54.30
N_1	51.16	77.14	82.65	98.06	124.13	86.63
N_2	63.05	87.00	94.37	113.27	136.96	98.93
N_3	73.84	102.43	107.41	129.19	151.49	112.87
Mean	55.34	78.50	84.23	100.03	122.82	88.18
		I		**N**		**I×N**
S.Ed (±)		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 2nd cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	43.08	54.26	62.19	67.66	87.65	62.97
N_1	61.90	88.00	94.98	110.82	143.76	99.89
N_2	76.56	97.39	105.15	123.95	150.67	110.74
N_3	84.72	111.70	120.22	141.94	170.62	125.84
Mean	66.57	87.84	95.64	111.09	138.18	99.86
		I		**N**		**I×N**
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 3rd cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	35.34	49.70	58.04	62.30	80.03	57.08
N_1	54.84	83.00	86.08	105.69	134.08	92.74
N_2	69.35	92.95	96.48	119.86	144.55	104.64
N_3	77.80	104.35	111.12	136.54	162.46	118.45
Mean	59.33	82.50	87.93	106.10	130.28	93.23
		I		N		I×N
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 (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	111.71	150.28	172.69	189.56	246.38	174.12
N_1	167.89	248.14	263.71	314.57	401.97	279.25
N_2	208.97	277.34	296.00	357.08	432.18	314.31
N_3	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

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

Treatments	Dry matter content (%)					
	1st Year			2nd Year		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Irrigation regimes (I)						
I_0	18.33	18.86	18.43	18.59	19.15	18.61
I_1	18.45	19.35	18.68	18.62	19.59	18.74
I_2	18.63	19.63	19.26	18.82	19.78	19.21
I_3	19.31	20.17	19.29	19.44	20.40	19.53
I_4	19.48	20.22	19.65	19.57	20.54	19.57
S.Ed (±)	1.16	1.11	1.16	0.90	0.72	0.81
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen levels (N)						
N_0	18.54	19.35	18.84	18.74	19.52	19.10
N_1	18.75	19.48	18.63	19.03	19.90	18.61
N_2	18.88	19.62	19.34	19.14	19.82	19.25
N_3	19.18	20.14	19.44	19.13	20.32	19.57
S. Ed (±)	0.67	0.64	0.70	0.71	0.62	0.66
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (I×N)						
S.Ed (±)	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

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)							
	1st Year				2nd Year			
	1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Total
Irrigation regimes (I)								
I_0	10.09	12.43	10.87	33.39	10.18	12.74	11.00	33.95
I_1	14.25	17.04	14.98	46.26	14.80	17.27	15.52	47.59
I_2	15.90	18.95	17.09	52.35	15.91	19.05	17.23	51.44
I_3	18.52	22.53	20.69	61.74	19.76	22.94	20.91	63.59
I_4	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
Nitrogen levels (N)								
N_0	8.77	12.66	11.27	33.37	10.26	12.39	11.31	33.83
N_1	16.33	20.14	17.98	54.78	16.70	19.99	17.61	53.85
N_2	18.75	22.45	21.05	62.25	19.03	22.21	20.43	61.66
N_3	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
Interaction (I×N)								
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

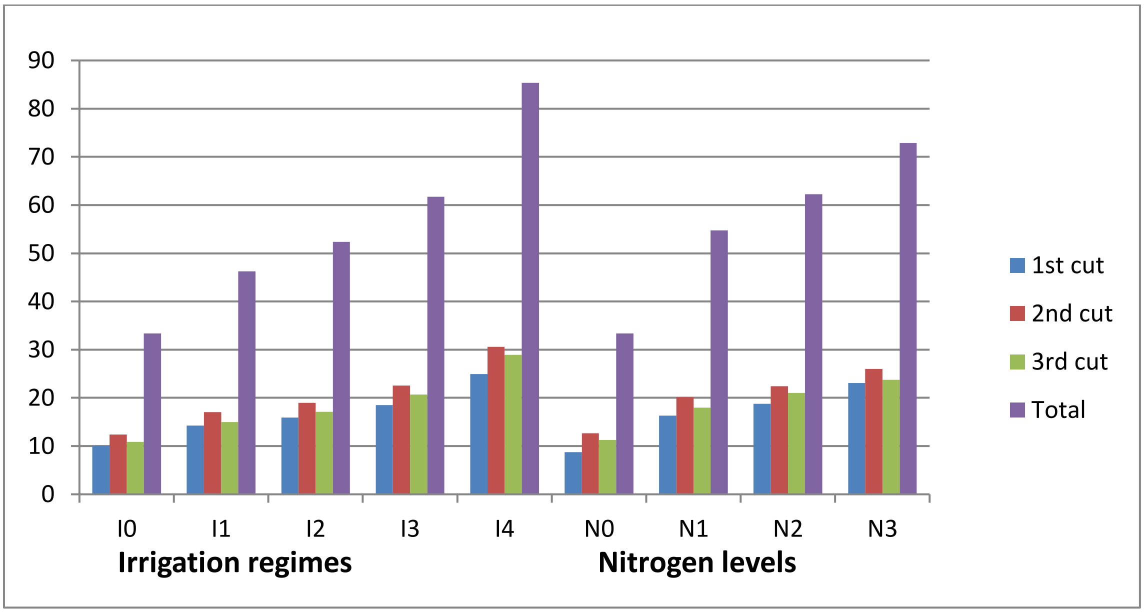

Fig. 3. Indicating the effect of irrigation regimes and nitrogen levels on dry matter yield (q/ha) of ryegrass (1st year)

3.8 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 1st cut, 2nd cut, 3rd 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.

3.9 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.

3.10 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 [34]. 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*. [25] also reported that increase in fertility level upto 150 kg N ha^{-1} increased both green and dry fodder yields. The abundant supply of nitrogen may have increased protoplasmic constituents and accelerated the process ofcell division and elongation, which has resulted in luxuriant vegetative growth in terms of plant height, thereby, higher biomass and dry matter yield [35].

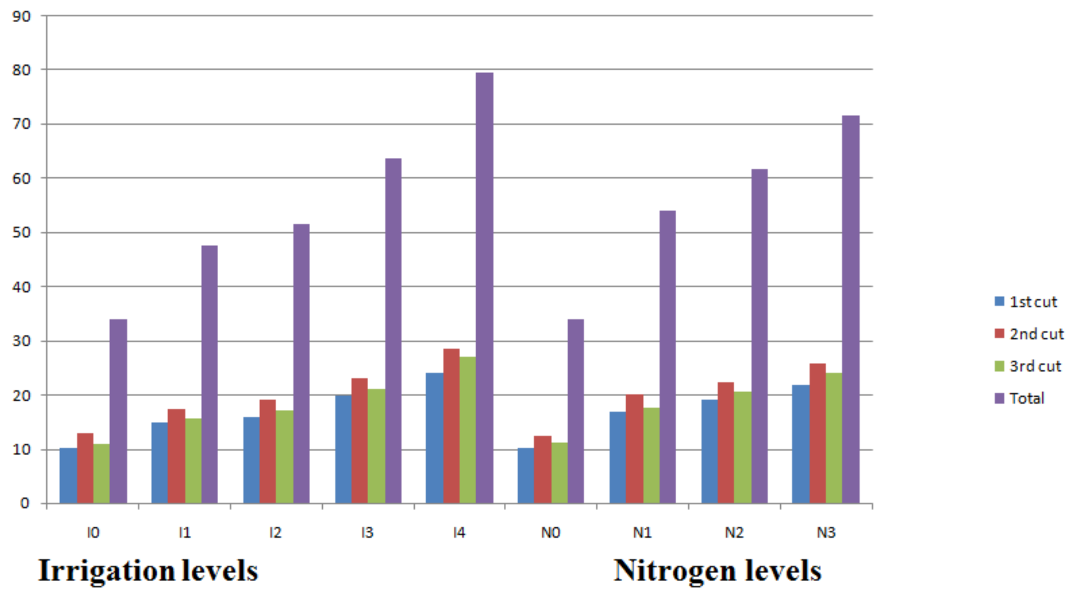

Fig 4. Indicating the effect of irrigation regimes and nitrogen levels on dry matter yield (q/ha) of ryegrass (2nd year)

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

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	5.33	7.1	8.24	8.05	15.14	8.77
N_1	8.99	13.55	16.22	18.28	24.61	16.33
N_2	12.03	15.49	16.93	21.43	27.89	18.75
N_3	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 2nd cut (1st year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	8.23	10.25	11.82	11.98	21.01	12.66
N_1	11.34	16.47	19.93	22.94	30.00	20.14
N_2	14.45	18.73	19.74	25.55	33.79	22.45
N_3	15.70	22.70	24.33	29.64	37.65	26.00
Mean	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 3rd cut (1st year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	6.70	9.06	11.10	10.65	18.86	11.27
N_1	9.72	15.12	16.87	20.79	27.38	17.98
N_2	13.59	16.51	18.04	23.68	33.42	21.05
N_3	13.49	19.22	22.32	27.65	36.13	23.76
Mean	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 (1st year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	20.26	26.41	31.16	30.68	58.35	33.37
N_1	30.05	45.14	54.68	62.02	81.99	54.78
N_2	40.06	50.74	54.71	70.66	95.10	62.25
N_3	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 1st cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	6.43	8.77	9.89	10.41	15.79	10.26
N_1	9.27	14.36	16.36	19.57	23.92	16.70
N_2	12.05	16.58	16.78	22.82	26.92	19.03
N_3	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 2nd cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	8.49	10.52	12.02	12.28	18.66	12.39
N_1	11.72	17.13	19.90	23.24	27.97	19.99
N_2	14.81	18.78	19.86	25.90	31.68	22.21
N_3	15.95	22.64	24.41	30.32	35.44	25.75
Mean	12.74	17.27	19.05	22.94	28.44	20.09
		I		**N**		**I×N**
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 3rd cut (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	6.78	9.40	12.04	11.32	17.00	11.31
N_1	9.79	15.39	16.60	21.06	25.22	17.61
N_2	13.72	16.95	18.07	23.46	29.94	20.43
N_3	13.72	20.34	22.20	27.80	35.46	23.90
Mean	11.00	15.52	17.23	20.91	26.91	18.31
		I		**N**		**I×N**
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 (2nd year)

Nitrogen levels (N)	Irrigation regimes (I)					Mean
	I_0	I_1	I_2	I_3	I_4	
N_O	21.71	28.69	33.29	34.01	51.46	33.83
N_1	30.88	46.87	50.53	63.87	77.11	53.85
N_2	40.58	52.31	54.72	72.19	88.53	61.66
N_3	42.64	62.48	67.23	84.30	100.67	71.46
Mean	33.95	47.59	51.44	63.59	79.44	55.20
		I		**N**		**I×N**
S.Ed (±)		2.29		2.12		4.74
CD (P=0.05)		5.28		4.89		9.67

3.11 Interaction Effect

The interaction effect between irrigation regimes and nitrogen levels was found to differ significant 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 1st cut, 2nd cut and 3rd 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.

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^2 and number of leaves/m^2 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^2 and number of leaves/m^2 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^2 and number of leaves/m^2 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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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