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Research Article

Impact of Different Irrigation Regimes and Systems of Cultivation on Physiological Growth Parameters of Rice Cultivars

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ABSTRACT

A field experiment was conducted on a clay loam soil at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR), Rajendranagar, Hyderabad, Telangana during the kharif seasons of 2017 and 2018. to study the "productivity and water use efficiency of rice cultivars under different irrigation regimes and systems of cultivation" The treatments consisted of two irrigation regimes Alternate wetting and drying and Saturation as main plot treatments, three establishment methods System of Rice Intensification (SRI), Drum Seeding (DS) and Normal transplanting (NTP) as sub plot treatments and four Cultivars namely DRR Dhan 42, DRR Dhan 43, MTU-1010 and NLR-34449 as sub-sub plot treatments summing up to 24 treatment combinations laid out in split-split plot design with three replications. Among all cultivars NLR-34449 produced the highest leaf area index (4.22, 4.11 and 4.16) at 90 DAT, DRR Dhan 42 produced the significantly higher AGR at 30-60 DAT (0.39, 0.42 and 0.40) and NLR-34449 produced the significantly lower CGR at 30-60 DAS/DAT (8.96, 9.24 and 9.10) during 2017, 2018 and in pooled means, respectively. Among all rice cultivars, RGR at all the crop growth stages in both the years of study and in pooled means was statistically non-significant. The growth analysis, viz., LAI, AGR, CGR, and RGR were significantly recorded higher in SRI than DS and NTP during both the years of study.

Key words: *Rice, Cultivars, Leaf Area Index, Absolute Growth Rate, Crop Growth Rate and Relative Growth Rate, Irrigation regimes and Systems of cultivation.*

INTRODUCTION

Rice (*Oryza sativa* L.) is the foremost staple food for more than 50% of the world's population. It is estimated that by the year 2025, farmers in the world should produce about 60% more rice than at present to meet the food demands of the expected world population at that time[13]. It is widely grown in India due to its wider adaptability.

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Food security in India is closely linked to sustainable rice production as it contributes to more than 42 per cent of the total food grain production and is the staple food for more than two thirds of Indian population. However, adequate water availability for rice production is becoming a major problem owing to depleting groundwater levels, water quality degradation and rising demands from other sectors. Rainfall patterns in many areas are becoming more unreliable, with extremes of drought and flooding occurring at unexpected time. Traditional planting has been the most important and common method of crop establishment practice under irrigated lowland rice ecosystems in tropical Asia. In irrigated lowland rice which not only consumes more water but also causes wastage of water resulting in degradation of land. In recent years to tackle this problem, many methods of cultivation have been developed and one among them is System of Rice Intensification (SRI).

LAI is the component of crop growth analysis that accounts for the ability of the crop to capture light energy and is critical to understand the function of many crop management practices. Leaf area index can have importance in many areas of agronomy and crop production through its influence: light interception, crop growth, weed control, crop-weed competition, crop water use and soil erosion[10]. Growth and yield characteristics of any cultivar depend on genetic and environmental factors. Among the different production factors, varietal selection at any location plays an important role. Proper crop management depends on the growth characteristics of various varieties to get maximum benefit from new genetic material. Among the different water-saving irrigation methods in rice, the most widely adopted is alternate wetting and drying (AWD). Many of the rice cultivars vary in their performance under different systems of cultivation. Therefore present experiment was conducts for Physiological Parameters LAI, AGR, CGR and RGR of rice cultivars grown under different irrigation regimes and systems of cultivation for getting maximum yield of rice.

MATERIAL AND METHODS

The field experiment comprises of 24 treatment combinations conducted at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR) farm, Rajendranagar, Hyderabad during the *kharif* seasons of 2017 and 2018. located at 17^{o}19' N latitude, 78^{o}23' E longitude and an altitude of 542.3 m above mean sea level, It represents the Southern Telangana agro-climatic zone of Telangana state. According to Troll's climatic classification, it falls under semi-arid tropics (SAT). During the crop growth period, a total rainfall of 990.4 mm was received in 50 rainy days in the first year and 375.6 mm in 26 rainy days in the second year. The weekly mean maximum and minimum temperature an average of 30.4 ^{0}C, 31.2^{0}C and 19.9 ^{0}C, 18.2^{0}C during 2017 and 2018 respectively. The treatments consisted of two irrigation regimes Alternate wetting and drying and Saturation as main plot treatments, three establishment methods System of Rice Intensification (SRI) with spacing of 25 cm x 25 cm, Drum Seeding (DS) with spacing of 20 cm x 10 cm and Normal transplanting (NTP) with spacing of 20 cm x 15 cm as sub plot treatments and four Cultivars namely DRR Dhan 42, DRR Dhan 43, MTU-1010 and NLR-34449 as sub-sub plot treatments laid out in split-split plot design with three replications. The area of each gross plot was 7 x 3 m^{2}. Seedlings were transplanted with an average of one seedling per hill in the SRI method of planting. Application of 10 t FYM ha^{-1} was given uniformly to all the plots before final puddling and leveling. The recommended dose of phosphorus @ 60 kg P_2O_5 kg ha^{-1} as single super phosphate (SSP) was applied to all the treatments uniformly as basal and potassium @ 40 kg K_2O ha^{-1} as muriate of potash (MOP) was applied in two splits 75 per cent at basal and remaining 25 per cent at panicle initiation stages. Recommended dose of nitrogen (120 kg ha^{-1}) was applied through urea in three splits 50 per cent at basal, 25 per cent at tillering stages and remaining 25 per cent at panicle initiation stages

Plant observation such as LAI, AGR, CGR and RGR, were recorded at 30, 60 and 90 DAT and at harvest. To calculate LAI (Leaf area index) CGR (Crop growth rate) and RGR (Relative growth rate) following formula were used:

Leaf area index

Leaf area (cm^2) of three randomly selected hills from each plot was estimated at 30, 60 DAS and at 90 DAS by using LICOR -3100 automatic leaf area meter. The leaf area index (LAI) is the ratio of leaf area per plant to the ground occupied by each plant (spacing).

$$LAI = \frac{\text{Leaf area } (cm^2)}{\text{Ground area } (cm^2)}$$

Absolute growth rate (g day^{-1})

$$AGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are the dry weights (g) at times t_1 and t_2 in days, respectively.

Crop growth rate (g m^{-2} day^{-1})

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

Where, W_1 and W_2 are the values of dry weights of plant (g) harvested from equal but separate areas of ground, (P) at times t_1 and t_2 in days, respectively. CGR is expressed in g m^{-2} day^{-1}.

Relative growth rate (g g^{-1} day^{-1})

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

Where, W_1 and W_2 are the dry weights (g) at times t_1 and t_2 in days, respectively.
ln is natural logarithm. RGR is expressed in g g^{-1} day^{-1}

RESULTS AND DISCUSSION

Effect on growth analysis

The mean LAI, AGR, CGR and RGR was lower between 0-30 DAT, then increased slowly between 30-60 DAT, thereafter increasing linearly between 60-90 DAT and finally it decreased sharply towards harvest. The LAI AGR, CGR and RGR of rice increases as crop growth advances and reaches a maximum at about heading or flowering[15]. The development of LAI AGR, CGR and RGR reflected a sigmoid pattern of the growth. Physiological Parameters of growth and development as influenced by different rice cultivars as influenced by irrigation regimes and establishment methods are presented in Fig 1.

Effect of irrigation regimes

The LAI, AGR, CGR and RGR was not influenced significantly by irrigation regimes in all the growth stages during both the years of study and in pooled means. Alternative wetting and drying and saturation were at par with each other in all the growth stages. These results are in conformity with Sandhu *et al*.[9], Kumar *et al*.[5] and Sudhakara[12].

Effect of systems of rice cultivation

Leaf area index during both the years was not significantly different at 30 and 60 DAS/DAT. At 90 DAT, system of rice intensification registered significantly higher leaf area index (4.52, 4.85 and 4.95) over NTP and DS during both the years and in pooled means respectively. The mean percentage increases of LAI in SRI at 90 DAT was 11.68, 12.46 and 12.75 per cent during 2017, 2018 and in pooled means, respectively over NTP (Table 1). This might be due to planting in square geometry with wider spacing and single seedling which facilitated for better utilization

of the resources to obtain maximum leaf area. These results are in conformity with Borkar *et al.*[2], Pradeep[7], Hussain *et al.*[3], Sridevi and Chellamuthu[11]. Among systems of rice cultivation at 0-30, 30-60, 60-90 and 90 DAS/DAT-harvest the AGR, CGR and RGR was significantly recorded higher in SRI than DS and NTP during both the years of study (Table 2, 3 and 4). This was because of early vegetative growth due to planting of young seedlings raised in system of rice intensification and with better interception of solar radiation and greater net photosynthesis capacity might have contributed for higher crop growth rate. Biscoe and Gallagher[1]. reported that higher crop growth rate is usually upon rapid expansion of leaf area index to intercept available radiation in the growing season. Similar observations were also made by Pradeep[7], Hussain *et al.*[3], and Rajendran *et al.*[8].

Effect of rice Cultivars

There was no significant difference among rice cultivars at 30 and 60 DAT during both the years and in pooled means. Leaf area index of rice Cultivars found to be significant at successive crop growth stage at 90 DAT. The cultivar NLR-34449 produced the highest leaf area index (4.22, 4.11 and 4.16) at 90 DAT during 2017, 2018 and in pooled means, respectively. The lowest LAI were produced by rice cultivar DRR Dhan 42. The leaf area index in DRR Dhan 42 was mainly due to lower production of tillers at all growth stages. The results are in conformity with the findings of Ningaraju *et al.*[6], and Vijay[14]. Among all cultivars DRR Dhan 42 produced the significantly higher AGR at 30-60 DAS/DAT (0.39, 0.42 and 0.40) during 2017, 2018 and in pooled means, respectively. Lower CGR in the initial growth stage in all cultivars. Among all cultivars NLR-34449 produced the significantly lower CGR at 30-60 DAS/DAT (8.96, 9.24 and 9.10) during 2017, 2018 and in pooled means, respectively. The results are in conformity with the findings of Hussain *et al.*[4], Ningaraju *et al.*[6], and Vijay[14]. Among all rice cultivars, RGR at all the crop growth stages in both the years of study and in pooled means was statistically non-significant

Effect of interaction

The interaction effect of among irrigation regimes, systems of rice cultivation and rice Cultivars on LAI, AGR, CGR and RGR at all the growth stages in both the years and in pooled means was found to be statistically non significant.

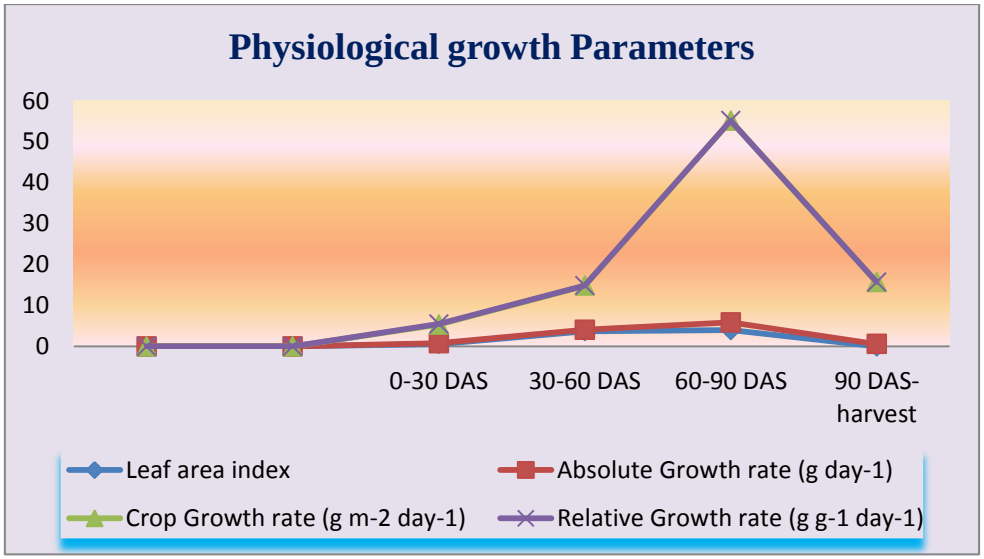

Fig. 1: LAI, AGR, CGR and RGR of rice as influenced by irrigation regimes, establishment methods and different cultivars during kharif 2017 and 2018 (pooled means)

Table 1: Leaf area index of rice as influenced by irrigation regimes, establishment methods and different cultivars during kharif 2017 and 2018

Treatments	Leaf area index								
	30 DAS			60 DAS			90 DAS		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Irrigation regimes (I)									
I_1: AWD	0.64	0.60	0.62	3.13	3.06	3.10	3.58	3.72	3.65
I_2: Saturation	0.57	0.55	0.56	5.20	3.46	4.33	4.79	4.16	4.32
S.Em±	0.04	0.03	0.04	0.32	0.13	0.71	0.46	0.05	0.13
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	0.28	NS
Systems of rice cultivation (S)									
S_1: SRI	0.64	0.71	0.67	2.21	2.11	2.16	4.52	4.85	4.95
S_2: DS	0.32	0.39	0.36	3.04	3.33	3.18	3.96	3.68	3.82
S_3: NTP	1.27	1.10	1.18	3.24	3.35	3.30	3.88	3.89	3.88
S.Em.±	0.05	0.04	0.05	0.68	0.14	0.88	0.47	0.08	0.15
C.D. at 5%	NS	NS	NS	NS	0.44	NS	1.54	0.27	0.49
Cultivars (C)									
C_1: DRR Dhan 42	0.59	0.53	0.56	3.67	3.34	3.48	3.68	3.73	3.71
C_2: DRR Dhan 43	0.66	0.59	0.62	3.09	3.22	3.15	4.11	4.00	4.05
C_3: MTU-1010	0.53	0.55	0.54	2.89	2.91	2.90	4.14	3.92	4.01
C_4: NLR-34449	0.66	0.62	0.64	4.01	3.59	3.80	4.22	4.11	4.16
S.Em.±	0.04	0.02	0.03	0.75	0.10	0.87	0.07	0.05	0.06
C.D. at 5%	NS	NS	NS	NS	0.29	NS	0.18	0.13	0.15
Interactions	NS	NS	NS	NS	NS	NS	NS	0.12	0.25
General Mean	0.61	0.57	0.59	4.17	3.26	3.71	4.19	3.94	3.98

Table 2: Absolute Growth rate (g day^{-1}) of rice as influenced by irrigation regimes, establishment methods and different cultivars during kharif 2017 and 2018

Treatments	Absolute Growth rate (g day^{-1})											
	0-30 DAS/DAT			30-60 DAS/DAT			60-90 DAS/DAT			90 DAS/DAT-At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Irrigation regimes (I)												
I_1: AWD	0.16	0.19	0.18	0.37	0.37	0.37	1.84	2.01	1.92	0.57	0.64	0.60
I_2: Saturation	0.16	0.19	0.17	0.35	0.37	0.36	1.66	2.11	1.89	0.50	0.67	0.58
S.Em±	0.01	0.01	0.01	0.00	0.01	0.01	0.03	0.12	0.07	0.01	0.04	0.03
C.D. at 5%	NS	NS	NS	NS	NS	NS	0.17	NS	NS	NS	NS	NS
Systems of rice cultivation (S)												
S_1: SRI	0.24	0.28	0.26	0.54	0.56	0.55	3.10	3.59	3.35	0.96	1.15	1.05
S_2: DS	0.13	0.15	0.14	0.32	0.31	0.32	0.87	1.02	0.94	0.24	0.29	0.27
S_3: NTP	0.22	0.23	0.22	0.22	0.24	0.23	1.28	1.58	1.43	0.41	0.52	0.46
S.Em.±	0.01	0.01	0.01	0.02	0.02	0.02	0.06	0.18	0.09	0.02	0.06	0.03
C.D. at 5%	0.05	0.02	0.03	0.07	0.05	0.06	0.19	0.57	0.28	0.06	0.20	0.10
Cultivars (C)..												
C_1: DRR Dhan 42	0.14	0.17	0.15	0.39	0.42	0.40	1.70	1.92	1.81	0.53	0.61	0.57
C_2: DRR Dhan 43	0.17	0.19	0.18	0.38	0.40	0.39	1.74	2.09	1.91	0.54	0.67	0.60
C_3: MTU-1010	0.15	0.18	0.17	0.34	0.35	0.34	1.82	1.94	1.88	0.55	0.60	0.57
C_4: NLR-34449	0.18	0.20	0.19	0.30	0.31	0.31	1.74	2.30	2.02	0.52	0.72	0.62
S.Em.±	0.02	0.01	0.01	0.02	0.01	0.02	0.04	0.24	0.12	0.01	0.08	0.04
C.D. at 5%	NS	0.03	NS	0.06	0.04	0.05	NS	NS	NS	NS	NS	NS
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	0.16	0.19	0.18	0.36	0.37	0.37	1.75	2.06	1.90	0.53	0.65	0.59

Table 3: Crop Growth rate (g m^{-2} day^{-1}) of rice as influenced by irrigation regimes, establishment methods and different cultivars during kharif 2017 and 2018

Treatments	Crop Growth rate (g m^{-2} day^{-1})											
	0-30 DAS/DAT			30-60 DAS/DAT			60-90 DAS/DAT			90 DAS/DAT-At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Irrigation regimes (I)												
I_1: AWD	4.17	5.05	4.61	10.90	10.80	10.85	47.79	52.66	50.22	14.56	16.45	15.50
I_2: Saturation	4.06	4.89	4.48	10.42	10.86	10.64	42.32	54.14	48.23	12.54	16.91	14.73
S.Em±	0.24	0.33	0.28	0.20	0.16	0.06	1.36	2.19	1.77	0.52	0.73	0.61
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Systems of rice cultivation (S)												
S_1: SRI	7.18	7.62	7.40	16.05	15.50	15.77	49.64	57.43	53.54	15.37	18.33	16.85
S_2: DS	3.26	3.73	3.00	8.58	9.00	8.79	43.40	50.78	47.09	11.90	14.67	13.29
S_3: NTP	3.90	4.55	4.23	7.34	8.00	7.67	42.13	51.99	47.06	13.38	17.04	15.21
S.Em.±	0.34	0.23	0.25	0.58	0.40	0.47	1.10	2.07	1.58	0.34	1.40	0.71
C.D. at 5%	1.11	0.75	0.81	1.88	1.30	1.54	3.58	4.02	3.80	1.12	NS	2.32
Cultivars (C)												
C_1: DRR Dhan 42	3.70	4.40	4.05	12.40	12.18	12.29	44.11	50.81	47.46	13.68	16.07	14.88
C_2: DRR Dhan 43	4.50	5.00	4.75	11.28	11.56	11.42	44.58	57.44	51.01	13.73	18.27	16.00
C_3: MTU-1010	3.73	4.78	4.25	10.00	10.34	10.17	45.74	49.72	47.73	13.44	15.22	14.33
C_4: NLR-34449	4.52	5.71	5.11	8.96	9.24	9.10	45.79	55.63	50.71	13.37	17.14	15.25
S.Em.±	0.42	0.30	0.35	0.59	0.40	0.48	1.06	5.19	2.72	0.32	1.76	0.94
C.D. at 5%	NS	NS	NS	1.67	1.14	1.35	NS	NS	NS	NS	NS	NS
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	4.11	4.97	4.54	10.66	10.83	10.74	45.06	53.40	49.23	13.55	16.68	15.12

Table 4: Relative Growth rate (g g^{-1} day^{-1}) of rice as influenced by irrigation regimes, establishment methods and different cultivars during kharif 2017 and 2018

Treatments	Relative Growth rate (g g^{-1} day^{-1})											
	0-30 DAS/DAT			30-60 DAS/DAT			60-90 DAS/DAT			90 DAS/DAT-At harvest		
	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled	2017	2018	Pooled
Irrigation regimes (I)												
I_1: AWD	0.1671	0.1715	0.1696	0.0417	0.0428	0.0423	0.0208	0.0214	0.0211	0.0026	0.0026	0.0026
I_2: Saturation	0.1619	0.1671	0.1645	0.0404	0.0417	0.0411	0.0202	0.0208	0.0205	0.0025	0.0026	0.0025
S.Em±	0.0097	0.0121	0.0109	0.0024	0.0030	0.0027	0.0012	0.0015	0.0013	0.0001	0.0001	0.0001
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Systems of rice cultivation (S)												
S_1: SRI	0.1837	0.1911	0.1874	0.0459	0.0477	0.0468	0.0229	0.0238	0.0234	0.0028	0.0029	0.0029
S_2: DS	0.1606	0.1710	0.1658	0.0401	0.0427	0.0414	0.0200	0.0213	0.0207	0.0025	0.0026	0.0025
S_3: NTP	0.1510	0.1576	0.1543	0.0377	0.039	0.0385	0.0188	0.0191	0.0192	0.0023	0.0024	0.0024
S.Em.±	0.0118	0.0128	0.0123	0.0029	0.0032	0.0030	0.0014	0.0016	0.0015	0.0001	0.0002	0.0001
C.D. at 5%	0.0385	0.0419	0.0402	0.0096	0.0104	0.0100	0.0048	0.0052	0.0050	0.0006	0.0006	0.0006
Cultivars (C)												
C_1: DRR Dhan 42	0.1678	0.1591	0.1635	0.0419	0.0397	0.0408	0.0209	0.0198	0.0204	0.0026	0.0024	0.0025
C_2: DRR Dhan 43	0.1635	0.1601	0.1618	0.0408	0.0400	0.0404	0.0204	0.0200	0.0202	0.0025	0.0025	0.0025
C_3: MTU-1010	0.1515	0.1632	0.1573	0.0378	0.0408	0.0393	0.0189	0.0204	0.0196	0.0023	0.0025	0.0024
C_4: NLR-34449	0.1752	0.1838	0.1795	0.0438	0.0459	0.0448	0.0219	0.0229	0.0224	0.0027	0.0028	0.0028
S.Em.±	0.0113	0.0087	0.0100	0.0028	0.0021	0.0025	0.0014	0.0010	0.0012	0.0001	0.0001	0.0001
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	0.1647	0.1694	0.1670	0.0411	0.0423	0.0417	0.0205	0.0211	0.0208	0.0025	0.0026	0.0026

CONCLUSION

Result revealed that the growth analysis, *viz.*, LAI, AGR, CGR, and RGR were significantly recorded higher in SRI than DS and NTP during both the years of study. The average leaf area index (LAI) of the rice increased at a slower rate up to 30 DAT and thereafter it increased steadily with the ontogeny of the plant reaching a peak value at 60 DAT, but there after it decreased gradually towards maturity due to senescence of leaves. The mean AGR, CGR and RGR was lower between 0-30 DAT, then increased slowly between 30-60 DAT, thereafter increasing linearly between 60-90 DAT and finally it decreased sharply towards harvest under semi arid tropical climatic condition on clay loam soil at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR), Rajendranagar, Hyderabad, Telangana during the *kharif* seasons of 2017 and 2018.

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