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Response of upland irrigated rice (*Oryza sativa* L.) varieties to irrigations

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Abstract
A field investigation entitled "Response of upland irrigated rice varieties to irrigations" was conducted at Plot No. 66, Research Farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Kharif* season of 2016-2017. The main plot treatments were: I_1- Irrigation at 0.6 IW/CPE, I_2- Irrigation at 0.8 IW/CPE, I_3-Irrigation at 1.0 IW/CPE and I_4-Irrigation at 1.2 IW/CPE and in the subplots, varietal trial was carried out, which consisted of four varieties: V_1- Variety Avishkar V_2- Variety Parag, V_3- Variety Sindewahi-1 and V_4- Variety PBNR-03-02. The experimental results revealed that the rice varieties performed best at 1.2 IW/CPE, in which irrigation water was provided when cumulative pan evaporimeter reading reached 50 mm. The yield attributes, grain yield, straw yield and the biological yield were observed to be the highest with 1.2 IW/CPE. Among the varieties, the variety Avishkar, was found to perform the best in terms of yield attributes like number of panicles, weight of panicle, number of filled spikelets and test weight which resulted in highest grain yield in the variety. All the varieties responded well to irrigations and the maximum yield and other characteristics were observed at higher irrigation levels. The variety Avishkar was found to perform the best under the upland irrigated conditions with 50 cumulative pan evaporation.

Keywords: upland rice, irrigation, cumulative pan evaporation, varieties

Introduction
Rice (*Oryza sativa*) being the staple food of almost two thirds of the population plays a pivotal role in Indian economy. India ranks first in the world in area of rice cultivation with 43.97 million ha and second in production with 104.32 million tons. In Asia, more than 75% of the annual rice supply comes from 79 million ha of irrigated paddy land. Thus, the present and future food security of Asia depends largely on the irrigated rice production system. However, rice is a profligate user of water. It takes 3,000 to 5,000 L to produce 1 kg of rice, which is about 2 to 3 times more than the amount needed to produce 1 kg of other cereals such as wheat or maize (Bouman *et al*., 2001) [2]. Irrigation water is an important production factor in rice systems but water is no longer available in unlimited rice-growing areas.

The productivity of the upland rice is very low because of a host of problems among which soil moisture stress is the most important. Kato *et al.* (2006) [4] studied on the growth of three rice cultivars under upland conditions with different levels of water supply found that the total water supply greatly affected the total dry matter in uplands. Another limitation with the cultivation of upland rice is that the yield potential of upland rice cultivars is far less as compared to that of the wetland rice cultivars, which limits its cultivation in most of the dryland tracts. The quality rice cultivars are also rare in the upland conditions. And also, the quality and trust of upland cultivars are been preferred by illite group in market. The yield of rice under upland conditions can be increased by judicious management of production inputs. Sokoto *et al*. (2013) [12] conducted a pot experiment to study the responses of rice varieties to water stress (FARO 44, NERICA 2 and FARO 15). The results indicated that there are significant differences among the genotypes. FARO 44 differed significantly from others in plant height, number of leaves per plant and total biomass.

Materials and Methods
The field experiment was carried out in Agronomy farm, Dr. Panjabro Deshmukh Vidyapeeth, Akola during kharif season of 2016-2017. The field was clayey in texture and was slightly alkaline in nature (pH 7.2), moderate in organic carbon (0.67%), low in available Nitrogen (218 Kg/ha), low in Phosphorous (18.4 Kg/ha) and high in available Potassium (337 Kg/ha). Rainfall received during the cropping season was 832.3 mm in 43 rainy days. During the crop growing season, the maximum temperature ranged between 30.2^{0}C in the 32nd meteorological week to 34.1^{0}C in 26th meteorological week.

The minimum temperature varied from 11.2^{0}C in the 45th meteorological week to 24.8^{0}C in the 27th meteorological week. The Relative Humidity was higher (92.1%) during the 40th meteorological week and 80% during the 26th meteorological week. Bright sunshine hours was the highest (8.9) in 42nd MW and the lowest (1.1) in 27th MW. The experiment was laid out in Split Plot Design with sixteen treatments replicated thrice. The treatments were allotted randomly in each replication. The main plot size was 13.00m x 10.00m and the subplot size was 5.00m x 4.50m. The main plots consisted of irrigation at four different levels I_1, I_2, I_3 and I_4 with IW/CPE of 0.6, 0.8, 1.0 and 1.2 respectively. The sub plot treatments were four varieties viz., Avishkar, Parag, Sindewahi-1 and PBNR-03-02. Sowing of seeds of varieties like Avishkar, Parag, Sindewahi-1 and PBNR-01-02 were done by drilling as per the treatments on 30th June 2016. A common irrigation was given before planting for good emergence. Later irrigation was given as per the treatments. The discharge of water through the pipe was measured by using watermeter. The fertilizers were applied as per the recommended dose. The recommended dose of fertilizer 100:50:50 Kg/ha. Top dressing with urea was done 35 DAS. Harvesting was done when the crop showed physiological maturity and the grains were completely matured Five plants were randomly selected from each plot, treatment wise from all the replications. The plants were labelled and various biometric observations were recorded on these plants periodically after 20 days of interval till maturity of the crop. Observations on yield components were recorded after the harvest of crop. The data collected during the course of experiment was statistically analyzed by adopting a standard method known as “Analysis of variance”.

Results and Discussions

Plant growth characteristics

Effect of treatments on plant height: Data on plant height at various growth stages as influenced by different treatments are graphically depicted in Fig. 1 The mean plant height was found to increase progressively up to 80 DAS, and after that, no further increase in plant height was observed till harvest. The rate of increase was moderate in between 0 - 20 DAS and rapid in between 20 – 40 DAS and 40 - 60 DAS and after that it hastened when it entered the reproductive stage. Effect of irrigation levels was found to be significant at all the stages 40, 60, 80 DAS and at harvest, except at 20 DAS. The results are in conformity with the findings reported by Biswas and Bhatacharya (1987) [1]. Interaction effect of the treatments was found to be non-significant in respect of plant height at all stages of the crop growth.

Effect of treatments on the number of functional leaves per plant: Data on the number of functional leaves per plant as influenced by the treatments are depicted graphically in Fig.1. The number of functional leaves per plant was found to increase progressively up to 60 DAS and was static from 60 DAS to 80 DAS and afterwards it showed a declining trend from 60 DAS till harvest. The number of functional leaves were found to be maximum at 60 DAS when the crop was in the grand growth stage. Leaf production was influenced significantly due to the interaction of irrigations and varieties also.

Effect of treatments on Leaf Area Index: Data on the Leaf area index as influenced by the treatments are depicted graphically in Fig.1.The Leaf area index was found to increase progressively up to 60 DAS and slightly decreased from 60 DAS to 80 DAS and afterwards it showed a declining trend from 80 DAS till harvest. The Leaf area index was found to be maximum at 60 DAS when the crop was in the grand growth stage. Interaction effect of the treatments was found to be non –significant at all the stages of crop growth in respect of Leaf area index.

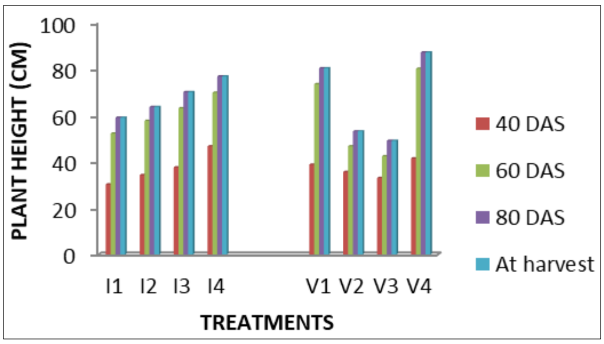
Effect of treatments on dry matter weight of the crop

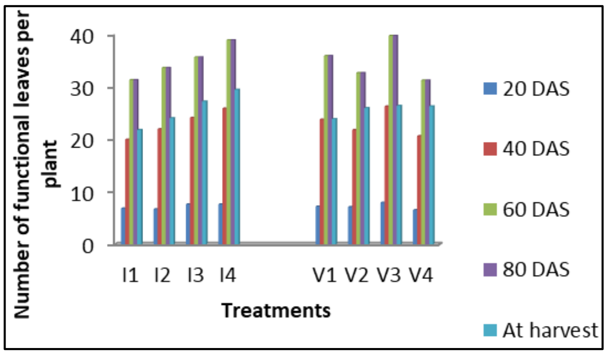
Irrigation levels was found to have significant influence on the dry matter weight of the crop at all stages, 40 DAS, 60 DAS, 80 DAS and at harvest, except at 20 DAS, where the effect of irrigation levels on dry matter weight was found to be non-significant. Higher irrigation levels were found to measure more dry matter weight as compared to lower irrigation levels. Varietal differences were found to have significant influence on the dry matter weight of the crop as depicted in the graph.

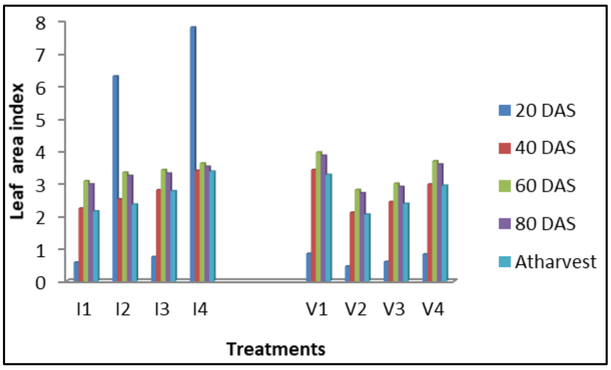
Yield attributes and yield

Results of the study revealed that the levels of irrigation and varietal differences exerted significant influence on yield attributes viz., number of productive tillers per hill, length of panicle, weight of panicle, number of spikelets per panicle, number of filled grains per panicle, chaff percentage and test weight. All these characters except length of panicle were profoundly influenced by irrigation treatment. Irrigating the crop at an IW /CPE ratio of 1.2 recorded the highest value for all the yield attributing characters. A drastic reduction in all these characters was observed in plants under extended interval of irrigation. It might be due to the high soil moisture tension experienced throughout the crop growth period especially during critical stages which in turn might have restricted the development of reproductive phase of the crop. The results obtained also shows the different yield attributes as influenced by the varietal differences in the crop.

Effect of treatments on number of panicles: Irrigation interval significantly influenced the number of panicles of rice as shown in the Table 1. Irrigation scheduled at IW/CPE 1.2 (I_4),







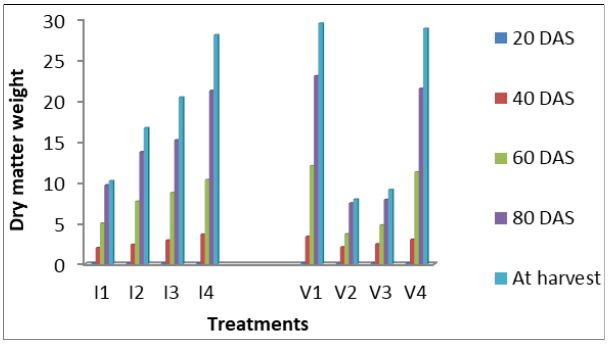


Fig 1: Plant height (cm), No. of functional leaves, Leaf Area Index and dry matter weight (g) as influenced by irrigation levels and varieties

In which the number of irrigations was the maximum and 1.0 IW/CPE produced maximum number of panicles (3), which was significantly superior over the number of panicles(2) in other irrigation levels I_2 and I_1. It was in accordance with the studies of Rahman and Yoshida (1985) [9], who observed that panicle exertion showed an inhibitory effect in lower irrigation levels, due to water stress under moisture stress conditions. Sudhakar *et al.* (1989) [13] reported that soil moisture stress during tillering stage resulted in significant reduction in panicle number. The number of panicles was also significantly influenced by the varieties. The maximum number of panicles (4) was observed in the variety Avishkar (V_2), which was significantly superior over other varieties. The least number of panicles (2) was shown by the varieties Parag (V_2) and Sindewahi (V_3).

Effect of treatments on the length of panicle: The effect of irrigations was found to be non-significant in respect of the length of the panicles as tabulated in Table 1. The number of panicles was significantly influence by the varieties. The longest panicle (24.41cm) was of V_4 (PBNR-03-02), which was significantly superior over Avishkar (23.57 cm), Parag (15.20 cm) and V_3 (15.07 cm).

Effect of treatments on the weight of panicle: The observations taken revealed that the weight of the panicle was the highest (3.17g) in the treatment with I_4 irrigation level (IW/CPE=1.2) and the lowest panicle weight was shown by the irrigation level with IW/CPE=0.6.The increase in the weight of the panicle in higher irrigation levels is due to the higher number of filled spikelets per panicle and higher test weight of the grains in case of treatments with higher irrigation levels. Weight of panicle was found to be the highest in Avishkar (3.39 g) and the lowest weight of panicle was found in the variety Parag. The interaction effect of the treatments in case of the weight of the panicles was found to be significant as shown in Table 1.

Effect of treatments on number of filled spikelets per panicle: The number of filled spikelets per panicle varied significantly with the irrigation levels. In the treatment, which received the maximum amount of irrigation, the number of filled spikelets were found to be the maximum. The observations taken revealed that the number of filled spikelets were maximum in 1.2 IW/CPE (147), which was significantly superior compared to that in I_1, I_2 and I_3 whose number of panicles are 94, 120 and 129 respectively. Shortage of assimilate supply due to inhibition of photosynthetic processes is one of the major factors determining grain filling (Matsushima and Wada, 1958; Yoshida, 1981) [7, 14]. The increased number of filled spikelets in treatments receiving higher number of irrigations, as compared to the treatments receiving lower number of irrigations is due to increased supply of assimilates under increased moisture supply. The varietal differences also contributed significantly to the number of filled spikelets. The number of filled spikelets were highest in case of Avishkar (138), which was significantly superior over Parag (107), Sindewahi-1(116) and PBNR-03-02 (128). Interaction effect of the treatments was found to be significant in respect of the number of filled spikelets per panicle, as per the data shown in the Table 1.

Effect of treatments on number of unfilled spikelets per panicle: Irrigation levels was found to have significant influence on the number of unfilled spikelets also. The treatments which received lowest amount of irrigation was found to have the maximum number of unfilled spikelets. Maximum number of unfilled spikelets was found in 0.6 IW/CPE (11), which was found to be significantly superior over 0.8 IW/CPE (10), 1.0 IW/CPE (9) and 1.2 IW/CPE (7). The grain sterility may be directly related to the stress experienced during flowering to panicle ripening. The deleterious effect of water deficit on spikelet opening might have resulted in high chaff percentage. It was in accordance with the studies of Lenka and Garnayak (1991) [6] and Ekanayake *et al*., (1989) [3]. Sudhakar *et al.* (1989) [13] reported that stress during development and ripening reduced the percentage of filled grains of rice. The different varieties showed different number of unfilled spikelets per panicle. The maximum number of unfilled spikelets per panicle was found in Parag (12), which was significantly superior over Avishkar (9), Sindewahi-1(4) and PBNR-03-02 (11).

Effect of treatments on the test weight of grains: Irrigation levels significantly influenced the test weight of the grains. Irrigation scheduled at 1.2 IW/CPE (21.25 g) recorded maximum test weight of grains, which was significantly superior over other treatments. The lowest test weight was recorded in 0.6 IW/CPE. The increase in test weight under the treatment 1.2 IW/CPE might be due to additional moisture supply due to application of frequent irrigations. Favourable plant water balance maintained through irrigation might have resulted in better translocation of photosynthates and maintenance of cell turgidity, consequently leading to higher yield traits. The result is in agreement with the study of Ramakrishna *et al* (2007) [10] and Parihar *et al* (2004) [8]. Different varieties also showed different test weights. Variety Avishkar (24.10 g) showed maximum test weight which was significantly superior over other varieties. Test weight of PBNR-03-02 (23.40 g) was significantly superior over Sindewahi-1(15.70 g). The lowest test weight was shown by the variety Parag (15.12 g)

Table 1: No. of panicles per plant, panicle length (cm), weight of panicle (g), No. of filled spikelets per panicle, No. of unfilled spikelets per panicle, Test weight of grains (g) as influenced by irrigation levels and varieties

Treatments	No. of panicles per plant	Panicle length (cm)	Weight of panicle (g)	No. of filled spikelets per panicle	No. of unfilled spikelets per panicle	Test weight of grain (g)
Main plot Irrigation levels						
I_1 (0.6 IW/CPE)	2.00	19.35	1.62	94.00	11.00	16.73
I_2 (0.8 IW/CPE)	2.00	18.84	2.37	120.00	10.00	19.49
I_3(1.0 IW/CPE)	3.00	19.75	2.70	129.00	9.00	20.86
I_4 (1.2 IW/CPE)	3.00	20.32	3.17	147.00	7.00	21.25
SE(m±)	0.16	0.54	0.01	0.63	0.28	0.09
CD (P=0.05)	0.55	NS	0.05	2.19	0.96	0.33
Subplot Varieties						
V_I (Avishkar)	4.00	23.57	3.32	138	9	24.10
V_2 (Parag)	2.00	15.20	1.65	107	12	15.12
V_3 (Sindewahi -1)	2.00	15.07	1.86	116	5	15.70
V_4(PBNR-03-02)	3.00	24.41	3.03	128	11	23.40
SE(m±)	0.15	0.72	0.022	0.60	0.40	0.06
CD (P=0.05)	0.43	2.11	0.07	1.75	1.17	0.18
Interaction						
I X V						
SE(m±)	0.29	1.44	0.04	1.20	0.80	0.12
CD(P=0.05)	NS	NS	0.13	3.51	NS	0.36
GM	2.75	19.57	2.47	122.52	9.52	19.58

IW – Irrigation water; CPE- Cumulative Pan Evaporation; NS- Non-significant at P>0.0

Effect of treatments on the grain yield of the crop

Irrigation levels had a significant influence on the grain yield of the crop as indicated in Table 2. Irrigation scheduled at 1.2 IW/CPE showed maximum grain yield (3653.08 Kg/ha) which was significantly superior over other irrigation levels. Irrigation at 1.0 IW/CPE (2312.95 Kg/ha) recorded significantly superior grain yield than irrigation at 0.8 IW/CPE and 0.6 IW/CPE. Minimum yield (1478.25 Kg/ha) was observed in irrigation at 0.6 IW/CPE. The reduction in crop yield at lesser irrigated treatment might be due to the severe and mild moisture stress experienced by the crop. Lee *et al* (1985) reported that yield reduction under moisture stress was mainly due to the increased number of unfilled grains per panicle rather than reduction in panicle number per unit area. Similar trend was also observed by Sheela (1993) [11]. The maximum yield was obtained from the variety Avishkar (3549.58 Kg/ha) and the lowest yield was obtained from the variety Parag (1404.29 Kg/ha).The interaction effect of the treatments was also found to be significant as indicated in the Fig. 2.

Effect of treatments on the straw yield of the crop

Irrigation levels were found to have significant influences on straw yield also. Straw yield was found to be the highest in irrigation scheduled at 1.2 IW/CPE (7933.33 Kg/ ha), which was significantly superior compared to other irrigation levels and the lowest at IW/CPE 0.6 (2910.25 Kg/ha). The increased straw yield with increasing levels of irrigation is attributed to the combined effect of plant height, tiller production and DMP, which were favourably influenced by irrigation levels. The straw yield of different varieties also varied significantly. Straw yield was found to be the maximum in case of PBNR-03-02 (8421.58 Kg/ha) and the minimum from the variety Parag (2064.92 Kg/ha). The interaction effect of the treatments was also found to be significant as per the data shown in the fig.3

Table 2: Grain yield (Kg/ha), Straw yield (Kg/ha) and Biological yield (Kg/ha) as influenced by irrigation levels and varieties

Treatments	Grain yield (Kg/ha)	Straw yield (Q/ha)	Biological yield (Q/ha)
Main plot Irrigation levels			
I1 (0.6 IW/CPE)	1478.25	2910.25	4388.50
I2 (0.8 IW/CPE)	2188.50	4736.08	6924.92
I3(1.0 IW/CPE)	2312.95	5761.42	8074.36
I4 (1.2 IW/CPE)	3653.08	7933.33	11586.41
SE(m±)	59.24	306.46	310.83
CD (P=0.05) Sub plot	205.03	1060.54	1075.65
Varieties			
VI (Avishkar)	3549.58	8366.50	11916.33
V2 (Parag)	1404.29	2064.92	3469.21
V3 (Sindewahi)	1593.75	2488.08	4081.37
V4 (PBNR-01-02)	3085.17	8421.58	11506.75
SE(m±)	41.05	306.08	302.72
CD (P=0.05)	119.84	893.42	883.61
Interaction			
I X V			
SE(m±)	82.12	612.16	605.44
CD(P=0.05)	239.69	1786.85	1767.23
GM	2408.19	5335.27	7735.53

IW- Irrigation Water; CPE-Cumulative Pan Evaporation; NS- Non-Significant

Effect of treatments on the biological yield of the crop

The biological yield was found to be the maximum in case of 1.2 IW/CPE (11586.41 Kg/ha), which was significantly superior compared to other irrigation levels. The biological yield obtained from irrigation level IW/CPE (8079.36 Kg/ha) was found to be significantly higher compared to the irrigation levels 0.8 IW/CPE (6929.92 Kg/ha) and 0.6 IW/CPE (4388.50 Kg/ha). The increased grain yield and straw yield in the irrigation, scheduled at 1.2 IW/CPE has resulted in highest biological yield in the treatment. The different genotypes also varied significantly in the biological yield. The variety Avishkar was found to yield the maximum (11916.33 Kg/ha), whereas the variety Parag recorded the lowest biological yield (3469.21 Kg/ha).

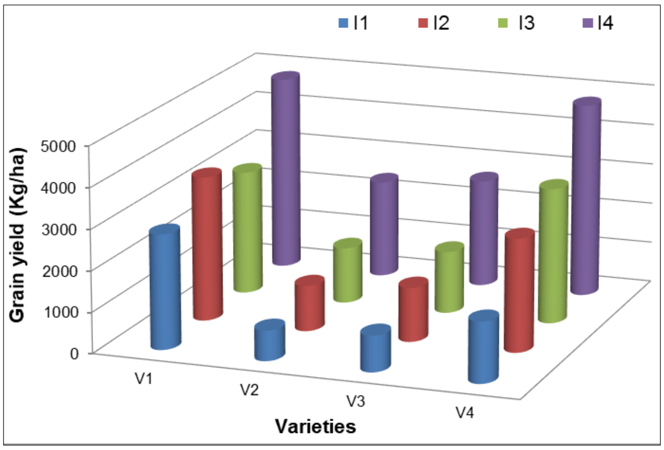


Fig 2: Interaction effect of irrigation levels and the varieties on the grain yield of the crop

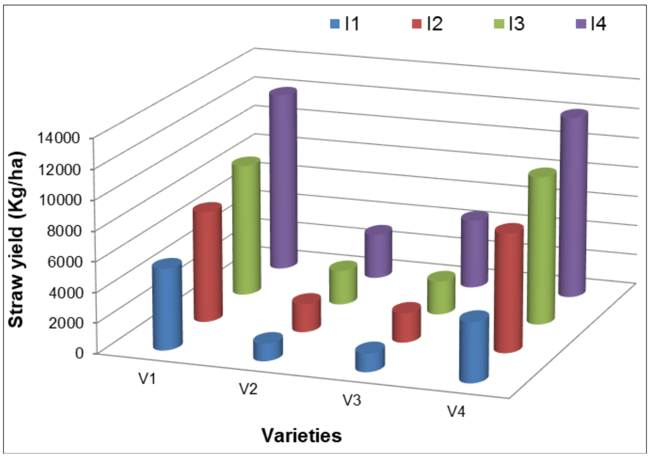


Fig 3: Interaction effect of irrigation levels and varieties on the straw yield of the crop

Summary and Conclusions

All the varieties responded well to the irrigation levels. Yield attributes like number of panicles, weight of panicle, number of filled spikelets per panicle, number of unfilled spikelets per panicle were found to be the maximum at 1.2 IW/CPE. Similarly the grain yield, straw yield and biological yield were found to be the maximum at irrigation provided at 1.2 IW/CPE. The yield attributes weight of panicle and test weight of grains were found to be the highest in variety Avishkar and the lowest in case of variety Parag. The highest grain yield, straw yield and biological yield were also observed in variety Avishkar. The interaction effect between the treatments, i.e., irrigation levels and varieties were found to have significant influence on the weight of panicle, number of filled spikelets, test weight of grains, grain yield, straw yield and biological yield.

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