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STUDIES ON DATES OF TRANSPLANTING, PGR'S ON GROWTH AND YIELD OF WATERMELON (*CITRULLUS LANATUS* THUNB.)

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ABSTRACT

The present investigation entitled "Studies on dates of transplanting, PGR's on growth and yield of watermelon (*Citrullus lanatus* Thunb.)" was carried during 2024-25 at Krishi Vigyan Kendra, Dr. Y. S. R Horticultural University, Pandirimamidi, Alluri Sitharamaraju District, Andhra Pradesh. The experiment was laid out in a factorial randomized block design (FRBD) which consists of two factors *viz.*, dates of transplanting at three levels (D_1: November last week, D_2: December last week and D_3: January last week) and foliar spray of plant growth regulators at five levels (P_0: Water spray, P_1: 0.1 ppm homobrassinolide, P_2: 0.5 ppm homobrassinolide, P_3: 0.5 mM salicylic acid and P_4: 1.0 mM salicylic acid) with two replications. The results were found significant for growth and yield parameters. The treatment combination T_7 (D_2P_1) *i.e.*, December last week + 0.1 ppm homobrassinolide recorded maximum vine length (316.31 cm), leaf area (212.06 cm^2), leaf chlorophyll content (56.25 SPAD units), fruit length (25.92 cm), fruit weight (4.19 kg), fruit yield per vine (12.73 kg) and minimum number of days taken for first female flower (33.40 days), node number at which first female flower (8.20), sex ratio (8.21) and days to first harvest from transplanting (73.70 days). T_{13} (D_3P_2) *i.e.*, January last week + 0.5 ppm homobrassinolide recorded minimum number of days taken for first male flower (23.20 days). T_8 (D_2P_2) *i.e.*, December last week + 0.5 ppm homobrassinolide recorded minimum node number at which first male flower (4.20). The lowest values for growth and yield parameters were recorded in T_1 (D_1P_0) *i.e.*, November last week + water spray.

Key words : Watermelon, Growth, Yield, Dates of transplanting, Plant growth regulators.

Introduction

Watermelon (*Citrullus lanatus* Thunb.) is an important crop that belongs to the Cucurbitaceae family and originates from tropical Africa, with a chromosome number of 2n = 22. It is cultivated in hot and dry areas, under both irrigated and rainfed conditions during the rabi and summer seasons. In India, watermelon accounts an area 0.12 million ha with production of 3.225 million metric tonnes. Andhra Pradesh rank first in area 17,160 ha and Uttarpradesh rank first in production 0.6969 million tonnes (NHB, 2022-2023). It is referred by various regional names like Tarbuj, Kalindi, Kalingada, Matira, Paniphal, Palampanna and Kalingaddi in different parts of the country. In southern India, it is typically cultivated from November to February during rabi season. It is primarily cultivated for its fresh juice and sweet flesh with the fruit being valued for its edible endocarp, rind, seeds and seed oil. The flesh of the watermelon is soft and spongy, displaying a range of colours such as reddish, pinkish, yellow and yellowish-white (Meshram *et al.*, 2022). According to the USDA nutrient database, watermelon fruit contains 93% water with small amounts of nutrients. 100 g of flesh contains energy (127 kJ / 30 k cal), carbohydrates (7.55 g), sugars (6.2 g), fibre (0.4 g), fat

(0.2 g), protein (0.6 g), vitamin A (569 IU), vitamin C (8.1 mg), calcium (7 mg), iron (0.24 mg) and lycopene (4532 µg). It is a rich source of lycopene and citrulline.

Maximum productivity can be obtained by cultivating watermelon under optimum weather conditions. It requires hot dry climate preferably with warm days and cool nights. It cannot withstand frost or very low temperatures that led to numerous physiological disturbances in the growth of the crop. For seed germination, an optimum moisture and a soil temperature between 25-30°C is needed. Similarly plant growth is optimum under 28-30 °C, while fruiting is better at 24-27°C. There are numerous reasons to change to transplanting because they reduce the seed use especially with expensive hybrids, earlier harvests, increased yields and precise establishment of crop which is necessary for uniform fruit size.

Plant growth regulators are other than the nutrients usually applied directly to a plant to modify the growth and sex expression which improve fruit set and ultimately increase yield. Exogenous application of PGR's can alter the sequence of male and female flower, when applied at true 2-4 leaf stages (Kumar *et al*., 2022). PGR's are very important for better growth, flowering and yield of watermelon (Sinojiya *et al*., 2015). Earlier only five groups of hormones (auxins, gibberellins, cytokinins, abscisic acid and ethylene) were designated as regulators of plant growth. However, in the recent past compelling evidences have been put forward to classify a group of steroidal substances (Brassinosteroids) as a new class of phytohormones.

BRs are now considered as a new class of plant hormones with significantly growth promoting activity. These were first isolated and characterized from the pollen of rape plants. This biologically active plant growth promoter was named as "Brassinolide" and was found to be steroidal lactone with an empirical formula of $C_{28}H_{48}O_6$. BRs are a group of naturally occurring polyhydroxy steroids. More than 60 BRs have so far been identified from different parts of plants such as pollens, seeds, leaves, stems, roots and flowers. In general, BRs can increase crop yield, crop quality and also play an important role in improving crop stress resistance. BRs cause marked biological effects at very low concentration *i.e.,* on micro molar concentrations (Li *et al*., 2021). There are large number of analogues of BRs and the most stable ones are epibrassinolide, homobrassinolide and brassinolide. However, some synthetic and commercial analogues of BRs are also available in the market (Zullo and Adam, 2002). Salicylic acid (SA) or ortho-hydroxy benzoic acid and other salicylates are known to affect various physiological and biochemical activities of plants and may play a key role in regulating their growth and productivity (Hayat *et al*., 2010). It acts as an endogenous hormone like plant growth regulator and plays a great role in secondary metabolism, which encourages the root growth, providing resistance against infection pathogenesis of the plant, inhibits the biosynthesis of ethylene and improves the quality of the crop.

Materials and Methods

The experiment was carried out during rabi season 2024-25 at Krishi Vigyan Kendra, Dr. Y. S. R Horticultural University, Pandirimamidi to study the effect of dates of transplanting and plant growth regulators on watermelon. It was laid out in a factorial randomized block design (FRBD) with two replications which consists of two factors *viz.*, dates of transplanting at three levels (D_1: November last week, D_2: December last week and D_3: January last week) and foliar spray of plant growth regulators at five levels (P_0: Water spray, P_1: 0.1 ppm homobrassinolide, P_2: 0.5 ppm homobrassinolide, P_3: 0.5 mM Salicylic acid and P_4: 1.0 mM Salicylic acid) consisting of fifteen treatment combinations *viz.*, T_1 (D_1P_0) - November last week + water spray, T_2 (D_1P_1) - November last week + 0.1 ppm HBR, T_3 (D_1P_2) - November last week + 0.5 ppm HBR, T_4 (D_1P_3) - November last week + 0.5 mM SA, T_5 (D_1P_4) - November last week + 1.0 mM SA, T_6 (D_2P_0) - December last week + water spray, T_7 (D_2P_1) - December last week + 0.1 ppm HBR, T_8 (D_2P_2) - December last week + 0.5 ppm HBR, T_9 (D_2P_3) - December last week + 0.5 mM SA, T_{10} (D_2P_4) - December last week + 1.0 mM SA, T_{11} (D_3P_0) - January last week + water spray, T_{12} (D_3P_1) - January last week + 0.1 ppm HBR, T_{13} (D_3P_2) - January last week + 0.5 ppm HBR, T_{14} (D_3P_3) - January last week + 0.5 mM SA and T_{15} (D_3P_4) - January last week + 1.0 mM SA.

Preparation of growth regulators

Preparation of different concentrations of Homobrassinolide solutions

0.25 ml of stock solution (0.04% W/W Homobrassinolide) is taken and add 1 litre of distill water to prepare 0.1 ppm HBR and 1.25 ml of stock solution (0.04% W/W Homobrassinolide) is taken and add 1 litre of distill water to prepare 0.5 ppm HBR solution. The solutions were prepared as per requirement.

Preparation of different concentrations of Salicylic acid solutions

69.06 mg of salicylic acid was dissolved in 1litre of 0.1N NaOH to prepare 0.5 mM SA solution and 138.12 mg of salicylic acid was dissolved in 1litre of 0.1N NaOH to prepare 1.0 mM SA solution. The powdered form of salicylic acid does not dissolve in water so it was dissolved in 0.1N NaOH solution. The solutions were prepared as per requirement.

The prepared plant growth regulators were sprayed at watermelon seedlings at true two leaf stage and subsequently on appearance of fourth leaf stage the second spray was given.

Length of the vine (cm)

The vine length of five randomly selected and labelled plants per plot was measured at final harvest by using measuring tape from collar region to the apical bud and their means was expressed in centimeters (cm).

Leaf area (cm^2)

Leaf area of five randomly selected plants per plot were measured by using Systronics leaf area meter 211 at final harvest and the average leaf area was expressed in square centimeters (cm^2).

Leaf chlorophyll content (SPAD units)

The leaf chlorophyll content was determined by non-destructive method using digital chlorophyll meter SPAD-502 Plus. The leaf chlorophyll content was recorded individually in each treatment at at final harvest and the average chlorophyll content in leaves was worked out and expressed in SPAD units.

Number of days taken for first female flower

This was recorded by counting the number of days taken from the date of transplanting to the opening of first female flower and mean values were computed.

Number of days taken for first male flower

This was recorded by counting the number of days taken from the date of transplanting to the opening of first male flower and mean values were computed.

Node number at which first female flower

The node number from the cotyledonous leaves to the node at which the first female flower appeared was recorded and expressed in numbers.

Node number at which first male flower

The node number from the cotyledonous leaves to the node at which the first male flower appeared was recorded and expressed in numbers.

Sex ratio

Total number of female and male flowers was counted by marking with help of tag and observation recorded at every 10 days intervals. Sex ratio was calculated by using the formula

$$\text{Sex ratio} = \frac{\text{Number of male flowers}}{\text{Number of female flowers}}$$

Days to first harvest from transplanting

Number of days taken from date of transplanting to first picking of matured fruits from the tagged plants in different treatments were recorded and expressed as days taken for first harvest.

Fruit length (cm)

The fruit length was measured with the help of scale from the stalk end to style end and average length was computed and expressed in centimeters (cm). Five fruits from tagged plants on each treatment were selected for measuring the fruit length.

Fruit weight (kg)

Five fruits from each treatment were selected randomly and weight was measured by using electronic weight balance and average fruit weight was worked out per plant and expressed in terms of kilograms.

Fruit yield per vine (kg)

The total weight of all marketable fruits obtained per vine was recorded and expressed in kilograms (kg).

During experimentation regular irrigation, weeding and plant protection measures were followed as per need of crop. The data obtained on various parameters were statistically analyzed by Factorial Randomized Block Design by Panse and Sukhatme (1967).

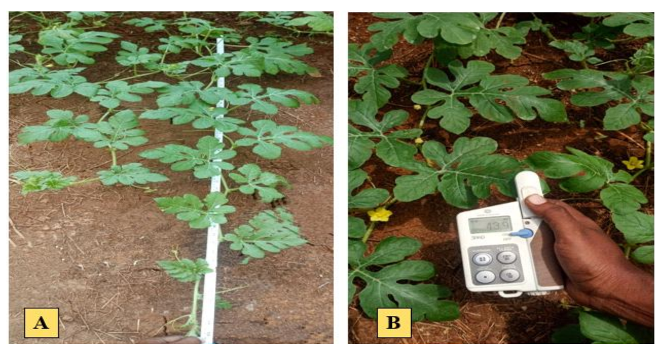

Fig. 1 : Measurement of growth parameters. **(A)** Measuring length of the vine by using measuring tape, **(B)** Leaf chlorophyll content was determined by non-destructive method by using digital chlorophyll meter SPAD-502 Plus.

Results and Discussion

The data presented in Tables 1, 2, 3 and 4 revealed that the growth and yield parameters of watermelon was significantly influenced by different dates of transplanting and foliar spray of plant growth regulators.

Growth parameters

Growth parameters were significantly influenced by different dates of transplanting. Across three different dates of transplanting, December last week recorded maximum vine length (305.99 cm), leaf area (203.44 cm^2) and leaf chlorophyll content (50.11 SPAD units).

Within five different concentrations of PGR's 0.1 ppm homobrassinolide recorded maximum vine length (306.14 cm), leaf area (205.49 cm^2) and leaf chlorophyll content (53.06 SPAD units).

Interactions were found significant for growth parameters. The treatment combination T_7 (D_2P_1) *i.e.*, December last week + 0.1 ppm homobrassinolide recorded maximum vine length (316.31 cm), leaf area (212.06 cm^2) and leaf chlorophyll content (56.25 SPAD units). The lowest values for growth parameters were recorded in T_1 (D_1P_0) *i.e.*, November last week + water spray.

The maximum increase in vine length, leaf area and leaf chlorophyll content was observed in plants transplanted during the last week of December, which might be due to the favourable temperature that promoted better growth and development of the watermelon. In contrast, poor growth was observed in the crop transplanted during the last week of November might be due to lower temperatures during the cropping period. Brassinolides might have attributed to increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products, thus resulting in increased cell elongation and rapid cell division in the growing portion (Dhall and singh, 2016). BRs helps to expand photosynthetic surface area in plants (Gudesblat and Russinova, 2011). Sakurai and Fujiok (1993) mentioned that the impact of brassinosteroids on leaf area might be related to its interaction with phytochrome, which governs growth regulation and triggers cell enlargement.

Yield parameters

Yield parameters were significantly influenced by different dates of transplanting. Among three different dates of transplanting, December last week recorded maximum fruit length (25.02 cm), fruit weight (3.76 kg), fruit yield per vine (10.14 kg) and minimum number of days taken for first female flower (35.40 days), node number at which first female flower (8.96), node number at which first male flower (4.98), sex ratio (8.72), days to first harvest from transplanting (75.04 days). January last week recorded minimum number of days taken for first male flower (24.98 days).

Within five different concentrations, 0.1 ppm homobrassinolide recorded maximum fruit length (25.44

Table 1 : Effect of dates of transplanting and plant growth regulators on length of the vine, leaf area and leaf chlorophyll content in watermelon cv. Arka Manik.

DOT (D)	Length of the vine (cm)						Leaf area (cm^2)						Leaf chlorophyll content (SPAD units)					
	PGR'S (P)						PGR'S (P)						PGR'S (P)					
	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D
D_1	271.58	298.38	282.63	278.58	287.28	283.69	181.35	197.98	191.56	188.53	194.51	190.78	42.50	48.51	45.08	43.63	46.60	45.26
D_2	296.38	316.31	305.81	301.74	309.71	305.99	193.35	212.06	203.63	197.97	210.23	203.44	45.59	56.25	48.55	47.04	53.16	50.11
D_3	282.28	303.74	291.61	288.63	296.47	292.54	186.60	206.45	196.60	192.94	201.97	196.91	44.29	54.44	45.74	44.55	52.32	48.26
Means of P	283.41	306.14	293.35	289.65	297.82		187.10	205.49	197.26	193.14	202.23		44.12	53.06	46.45	45.07	50.69	
Factors	SE (m) ±			CD at 5%			SE (m) ±			CD at 5%			SE (m) ±			C.D at 5%		
D	0.12			0.37			0.13			0.40			0.12			0.36		
P	0.15			0.47			0.17			0.52			0.15			0.47		
DXP	0.27			0.83			0.29			0.90			0.27			0.82		

Fig. 2 : General view of the watermelon fruits. D_1P_0: November last week + water spray, D_2P_1 : December last week + Homobrassinolide (0.1 ppm).

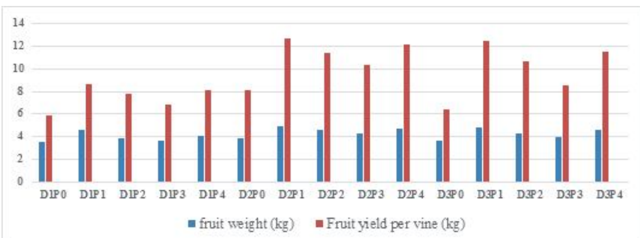

Fig. 3 : Effect of dates of transplanting and plant growth regulators on fruit weight and fruit yield per vine in watermelon cv. Arka Manik.

cm), fruit weight (4.07 kg), fruit yield per vine (10.60 kg) and minimum number of days taken for first female flower (36.16 days), node number at which first female flower (9.10), sex ratio (8.36) and days to first harvest from transplanting (76.70 days). 0.5 ppm homobrassinolide recorded minimum number of days taken for first male flower (25.23 days) and node number at which first male flower (4.93).

Interactions were found significant for the following yield parameters. The treatment combination T_7 (D_2P_1) *i.e.*, December last week + 0.1 ppm homobrassinolide recorded maximum fruit length (25.92 cm), fruit weight (4.19 kg), fruit yield per vine (12.73 kg) and minimum values were recorded for number of days taken for first female flower (33.40 days), node number at which first female flower (8.20). sex ratio (8.21) and days to first harvest from transplanting (73.70 days). T_{13} (D_3P_2) *i.e.*, January last week + 0.5 ppm homobrassinolide recorded minimum number of days taken for first male flower (23.20 days). T_8 (D_2P_2) *i.e.*, December last week + 0.5 ppm homobrassinolide recorded minimum node number at which first male flower (4.20). The lowest values for yield parameters were noticed in T_1 (D_1P_0) *i.e.*, November last week + water spray.

Table 2 : Effect of dates of transplanting and plant growth regulators on number of days to first female flower, number of days to first male flower and node number at which first female flower in watermelon cv. Arka Manik.

DOT (D)	Number of days to first female flower						Number of days to first male flower						Node number at which first female flower					
	PGR'S (P)						PGR'S (P)						PGR'S (P)					
	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D
D_1	42.10	39.80	40.40	41.30	40.10	40.74	32.10	27.70	27.40	28.80	29.10	29.02	10.70	9.60	10.10	10.50	9.90	10.16
D_2	37.30	33.40	35.20	36.50	34.60	35.40	28.60	25.80	25.10	26.30	27.50	26.66	10.20	8.20	8.70	9.30	8.40	8.96
D_3	38.60	35.30	36.90	37.70	36.70	37.04	25.90	24.70	23.20	25.40	25.70	24.98	10.40	9.50	9.80	10.00	9.70	9.88
Means of P	39.33	36.16	37.50	38.50	37.13		28.86	26.06	25.23	26.83	27.43		10.43	9.10	9.53	9.93	9.33	
Factors	SE (m) ±			C.D at 5%			SE (m) ±			C.D at 5%			SE (m) ±			C.D at 5%		
D	0.05			0.18			0.08			0.25			0.04			0.14		
P	0.07			0.23			0.10			0.32			0.06			0.18		
DXP	0.13			0.40			0.18			0.57			0.10			0.32		

D_1: November last week, D_2: December last week and D_3: January last week, P_0: Water spray, P_1: 0.1 ppm homobrassinolide, P_2: 0.5 ppm homobrassinolide, P_3: 0.5 mM Salicylic acid and P_4: 1.0 mM Salicylic acid

Table 3 : Effect of dates of transplanting and plant growth regulators on node number at which first male flower, sex ratio and days to first harvest from transplanting in watermelon cv. Arka Manik.

DOT (D)	Node number at which first male flower						Sex ratio						Days to first harvest from transplanting					
	PGR'S (P)						PGR'S (P)						PGR'S (P)					
	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D
D_1	7.10	5.40	5.70	6.50	6.30	6.20	10.63	8.58	8.89	9.46	8.66	9.24	84.20	80.50	81.30	82.60	81.20	81.96
D_2	5.60	4.70	4.20	5.30	5.10	4.98	9.86	8.21	8.58	8.65	8.30	8.72	76.40	73.70	75.30	75.80	74.00	75.04
D_3	6.90	5.50	4.90	6.40	6.00	5.94	10.52	8.29	8.80	9.30	8.43	9.07	79.50	75.90	78.00	78.80	77.70	77.98
Means of P	6.53	5.20	4.93	6.06	5.80		10.33	8.36	8.75	9.14	8.46		80.03	76.70	78.20	79.06	77.63	
Factors	SE (m) ±			C.D at 5%			SE (m) ±			C.D at 5%			SE (m) ±			C.D at 5%		
D	0.04			0.13			0.02			0.07			0.06			0.20		
P	0.05			0.17			0.03			0.09			0.08			0.26		
DXP	0.09			0.30			0.05			0.15			0.15			0.46		

Table 4 : Effect of dates of transplanting and plant growth regulators on fruit length, fruit weight and fruit yield per vine in watermelon cv. Arka Manik.

DOT (D)	Fruit length (cm)						Fruit weight (kg)						Fruit yield per vine (kg)					
	PGR'S (P)						PGR'S (P)						PGR'S (P)					
	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D	P_0	P_1	P_2	P_3	P_4	Means of D
D_1	21.79	24.66	23.74	22.80	24.25	23.44	2.86	3.94	3.20	2.93	3.39	3.26	4.92	7.64	6.75	5.89	7.14	6.47
D_2	23.70	25.92	25.10	24.89	25.51	25.02	3.13	4.19	3.93	3.54	4.04	3.76	7.11	12.73	10.38	9.30	11.17	10.14
D_3	22.18	25.75	24.32	23.65	24.80	24.14	2.92	4.10	3.58	3.27	3.91	3.55	5.38	11.44	9.64	7.52	10.51	8.89
Means of P	22.55	25.44	24.38	23.78	24.85		2.97	4.07	3.57	3.25	3.78		5.80	10.60	8.92	7.57	9.60	
Factors	SE (m) ±			C.D at 5%			SE (m) ±			C.D at 5%			SE (m) ±			C.D at 5%		
D	0.05			0.15			0.03			0.10			0.17			0.52		
P	0.06			0.19			0.04			0.13			0.21			0.67		
DXP	0.11			0.34			0.07			0.22			0.38			1.16		

D_1: November last week, D_2: December last week and D_3: January last week, P_0: Water spray, P_1: 0.1 ppm homobrassinolide, P_2: 0.5 ppm homobrassinolide, P_3: 0.5 mM Salicylic.

The application of brassinosteriods may also play a vital role in plant cell division, elongation, reproduction and further enhancing fruit yield (Gudesblat and Russinova, 2011; Wei and Li, 2016). The earlier studies suggested that brassinosteriods had effect on female flower development in watermelon are mediated by ethylene biosynthesis. This means that brassinolides may influence the ethylene levels by signalling the ethylene biosynthesis which impacts the female flower development (Susila *et al.,* 2012).

Anatomical studies of the sex organs revealed that the application of certain growth substances induce the transformation of staminate flower buds into pistillate flower buds. The endogenous levels of hormones in the plants are responsible for the modification of sex ratio in cucurbits. The node number at which first female flower appeared is an indication of sex modification (Susila *et al*., 2012). The treatment involving homobrassinolide at 0.1ppm resulted in significantly greater fruit length and yield per vine due to active metabolites and receive enhanced nutrient and metabolite supply from source to sink, originating from vegetative parts. So, hormones play a vital role in regulating the movement of metabolites and mineral elements within the plant, which could contribute to the observed increase in fruit size and fruit weight. The enhanced yield might be due to factors like increased vine length, leaf area and fruit weight (Wang *et al.,* 2019) that leads to higher yield.

Similar findings were reported by Susila *et al.* (2012), Sinojiya *et al.* (2015), Kumar *et al.* (2022) in watermelon, Sridhara *et al.* (2021) in tomato and Yadav *et al.* (2022) in cucumber for growth and yield parameters.

Conclusion

From the present study, it can be concluded that the maximum length of the vine, leaf area, chlorophyll content of leaf, fruit length, fruit weight, fruit yield per vine and the minimum values were recorded for number of days taken for first female flower, node number at which first female flower, sex ratio and number of days to first harvest from transplanting was observed in treatment combination of T_7 (D_2P_1) *i.e.,* December last week + 0.1ppm HBR recorded best results for growth and yield parameters.

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