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THE EFFECT OF FERTILIZER TYPE AND PLANT DENSITY ON GROWTH AND YIELD OF BROCCOLI *BRASSICA OLERACEA VAR. ITALICA L*

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ABSTRACT

The experiment was carried out during the autumn agricultural season 2019-2020 at the Research Station department of the Horticultural Department of the Faculty of Agriculture, University of Diyala to find out the effect of fertilizer type and plant density on the growth and outcome of broccoli (*Brassica oleracea* var. *Italic*. L) experiment included two factors the first represents plant density where the seedlings were planted at three agricultural distances which are (30, 40 and 50 cm) and the second factor represents the type of fertilizer where the first two types of fertilizer is used fertilizer (N-P-K) by (15-15-15) and the second by ratio (20-20-20) where the two fertilizers were added in the first two numbers (500 kg.ha^{-1}) and the second (750 kg.ha^{-1}) in addition to the non-addition transaction and thus the number of working transactions (15) transaction, used in the experiment design of the whole random sectors (R.C. B. D) Three repeaters and the statistical analysis program (SAS) was used and the results were compared using a multi-border toki test at a probability of 5%, and the results were as follows: 1-The transaction of fertilizer (N-P-K) was outperformed by (20-20-20) and by quantity (750 kg. ha^{-1}) in the characteristics studied the height of the plant and the number of leaves and the area of one sheet amounted (77.3 cm and 3 0.3 Leaf^{-1} and 661 cm^2) respectively, also outperformed the same transaction in diagonal and the weight of the main flowery disc and the product of the main flowery discs reached (23.7 cm, 596 g and 19.87 tons . ha^{-1}), respectively, while the non-addition transaction gave the least value to all the qualities studied. 2-The results showed the superiority of plants planted at a distance (50 cm) in the height of the plant and the number of leaves reached (75.8 cm and 27 leaves.plant^{-1}), respectively, as well as the distance of agriculture itself in diagonal and the weight of the main pink disc reached (20.6 cm and 567 g) respectively, the plants planted at a distance (30 cm) in the main pink discs exceeded (18.04 tons. Ha^{-1}) while the same planting distance gave the lowest values to all other studied qualities. 3-The overlap between the type of fertilizer and plant density had a moral effect, as the treatment of fertilizer interference (N-P-K) was greater than (20-20-20) and by (750 tons. Ha^{-1}) and the planting distance (50 cm) in the height of the plant and the number of leaves reached (83 cm and 31 leaves .plant^{-1}), respectively, also affected the treatment of the same interference in the diameter and weight and the product of the main pink discs, which reached (25 cm, 747 g and 19.92 tons .ha^{-1}), respectively, in When the transaction of interference not to add fertilizer and agriculture at a distance (30 cm) gave the lowest values for the attributes mentioned, except for the characteristic of the number of leaves, where the transaction of overlapping non-addition of fertilizer and agriculture at a distance (40 cm) was the lowest, the transaction of interference not to add fertilizer and agriculture at a distance (50 cm) gave the least value for the quantity of the total main flowery discs (11.00. tons.ha^{-1}).

Keywords: Fertilizer Type, Plant Density, Broccoli, *Brassica Oleracea Var. Italica* L

Introduction

Broccoli's scientific name (*Brassica oleracea* var. *Italica*. L) is an important winter vegetable belonging to the Crusader family (Brassicaceae), a herbaceous plant around me similar to the plant of cauliflower morphology known more than 2700 years ago in the Mediterranean and in the regions of Asia Minor (Hassan, 2004 and Decoteau, 2000). Broccoli is grown for its pink light, which is eaten in the phase of flowery buds before opening with its thick, juicy tripods and is one of the richest crops of the crusader family in nutritional value and the most widely used in terms of treatment because it is rich in many vitamins such as vitamins C, A, B1, B6 and B17 and mineral elements such as calcium, sodium, iron, zinc and manganese (Thapa and Rair, 2012). Moreover, broccoli is consumed as a controlled and antibiotic treatment for many common diseases, it helps to regulate blood sugar and lowers the level of cholesterol in it, it lowers high blood pressure, increases physical strength, helps build bones and has an important role in the prevention of heart diseases, urinary tract and genital tract. Cancer, which has been shown to reduce the risk of cancer by 45% and has an important role in preventing retinal diseases (Kirsh *et al.*, 2007; Zhao *et al.*, 2007). The good vegetative growth and high production of broccoli is influenced by several important factors, including chemical fertilizers, which increase the production rate by about 45% provided that they are balanced when added, including the major elements (N-P-K) which are very necessary during the stages of plant growth. Different and especially the stage of vegetative growth, flowers and nodes, the plant needs

nitrogen element during its early stages of growth as it works to build a good vegetable total it enters into the construction of proteins, enzymes, protoplasm and energy compound (ATP) which is important in the construction process Photosynthesis because it enters the synthesis of chlorophyll molecule, but phosphorus has an important role in many enzymatic reactions and it enters into the synthesis of nuclear acids such as (DNA and RNA) and enters In the synthesis of energy-rich phosphorus compounds (ATP and ADP) and has an important role in the growth and strengthening of the radical total because it enters the process of the formation and division of living cells and the transfer of genetic traits (Abu Dahi and Al-Younis, 1988 and Al-Nuaimi, 1999). Potassium is the third major element needed by the plant in large quantities as it has an important role in stimulating more than 65 enzymes related to many vital events within the plant, including improving the efficiency of the carbon representation process by forming an ATP molecule), and has an important role in promoting the growth of roots and despite its presence in the soil in large quantities, but a small percentage of it is ready to be absorbed by the plant, which makes it necessary to add it to the mass (Mengel and Kirkby, 1989 and Al-Jubouri, 2013). One of the important factors leading to increased production in the unit of space is the appropriate farming distances between plants that affect the extent to which a single plant benefits from various environmental factors such as nutrition, lighting, temperature, ventilation, humidity, etc. thus ensuring that the plant gets its need from these factors, which are reflected in the strength of vegetative growth and the amount of the achievement, and the appropriate planting distances facilitate crop service processes and control of diseases and insects (Al-Aiada, 1995).

Materials and Methods

1-The site of the implementation of the experiment and the collection of soil samples: the experiment was carried out during the winter agricultural season of 2019-2020 in the research station of the Department of Horticulture faculty of agriculture University of Diyala in order to study the effect of the type of fertilizer and plant density in the growth and the product of broccoli. Samples of the field soil were taken before planting in the form of an (X) and a depth (0-30 cm) and the samples were analyzed laboratory table (1)

2-Field preparation and planting of seedlings: the field was ploughed and followed by the process of leveling and softening and then adding a decomposing animal fertilizer by (20 23 tons / ha) and the field section to three terraces representing sectors, after which the drip irrigation system and the division of the terrace were installed into 15 sections representing experimental units length 2 (m) and width of 2.25 m) thus becoming the area of the experimental unit (4.5 m^2). Using the seeds of the broccoli hybrid (JASSMINE F1) seeds were cultivated on 12/8/2019 in cork dishes and after the completion of the growth of the seedlings moved to the field on 6/10/2019

3-Transactions and experimental design: The experiment consists of two factors the first factor is the type of fertilizer where used (M0) without adding fertilizer and (M1) is fertilizer (N-P-K) in proportions (15-15-15) in the amount of 500 kg/ha. (M^2) is fertilizer (N-P-K) in proportions (20-20-20) in the amount of 500 kg/ha. (M3) is fertilizer (N-P-K) in proportions (15-15-15) at 750 kg/ha. (M4) is fertilizer (N-P-K) in proportions (20-20-20) at 750 kg/ha. The second factor is plant density where the planting of broccoli seedlings at three different distances are: (T1) is a distance of 30 cm, this treatment contains 21 broccoli plants. (T2) is a distance of 40 cm, this treatment contains 15 broccoli plants. (T3) is a distance of 50 cm, this treatment contains 12 broccoli plants. Use the design of the entire random sectors (R. C. B. D) (Randomized Complete Block Design) with three repeaters and each repeater contains 15 transactions, bringing the number of experimental units to 45 experimental units. Use the Statistical Analysis Program (SAS 2012) and compare the arithmetic averages using a multi-border toki test at a probability of 5%

Well-studied qualities

A: Qualities of vegetative growth:

1-Plant height (cm): The height of the plant was measured using the measurement bar from the point of contact of the plant with the soil to the top of the longest leaf.

2-Number of leaves ($leaf^{-1}$): The total number of leaves of the selected plants was calculated randomly and then divided this number by the number of plants selected to extract the average number of leaves per plant.

3-Area of one leaf ($cm^2.leaf^{-1}$): 6 modern sheets were selected full-growth at the fifth node of the top and these papers were weighed to extract the stomach of the soft weight of one sheet of paper and then cut out of each sheet three discs known area and the weight of these discs was taken to extract the weight of the weight of the disk and then calculated the leaf area according to the following equation (Dvornic, 1965).

$$\text{Paper area} = \frac{\text{Full paper weight (g)X disk space (cmz)}}{\text{Weight of the cut disk (g)}}$$

B-The characteristics of the main flowery discs :

1-Diagonal of the main flowery disc (CM): The distance between the two most distant points on both sides of the flowery disc, which represents the diagonal of the flowery disc, was measured using the measuring tape.

2-Weight of the main flowery disc (g): The total gain of the main flowery discs and the weight section was weighed on the number of flowery discs weighted to extract the weight of the single flowery disc**.**

3-The total product of the main flowery discs (ton . ha^{-1})

Extract the total quotient by the following equation. X $10000m^2$

$$\frac{\text{the weight of the total outcome in the experimental unit}}{\text{experimental unit area m2}} \times$$

The amount of the outcome obtained per hectare

Table 1 : Some chemical and physical qualities of the soil of the field before planting the experiment in it.

Unit of measure	Quantity	Quality	
_	7.3	The degree of interaction – pH	
$ds.m^{-1}$	3.25	The degree of conductivity - EC	
%	1.03	Organic matter	
meq/l	2	Ready-made phosphorus	
ppm	263	Ready-made potassium	
ppm	26	Ready-made nitrogen	
%	28.5	Calcium carbonate	
%	43.2	Clay	Soil separates
%	30.16	alluvium	
%	26.64	Sand	
Loan clay		Soil texture	

Results and Discussion

1. Plant height (cm)

The results in table (3) showed that there is a moral effect of fertilizer transactions (N-P-K) in the height of the plant where the transaction (M4) exceeded the high moral superiority at the probability level (0.01) as it gave the highest height of the plant reached (77.3 cm) which did not differ morally from transactions (M3 and M2) while the transaction (M0) gave the lowest value of the height of the plant amounted to (67.7 cm). As for the effect of plant density on the height of the plant, the results show that there is a moral effect where the transaction of plant density (T3) exceeded the high moral superiority where it gave the highest value of the height of the plant reached (75.8 cm) which did not differ morally from the transaction (T2) while the transaction (T1) gave the lowest value of the height of the plant amounted to (69.2 cm).The overlap between N-P-K fertilizer transactions and plant density transactions had a moral effect, where the transaction of interference (M4 T3) exceeded the high moral superiority and gave the highest value of the characteristic of the height of the plant amounted to (83 cm) and gave the transaction (M0 T1) the lowest value of the height of the plant amounted to (65 cm).

2. Number of leaves (leaf.plant^{-1})

The results of table (4) indicate that there is a moral effect of the transactions of fertilizer N-P-K) in the number of leaves as the transaction (M4) exceeded the high moral superiority of all compost transactions by giving the highest value of the number of leaves (30.3 leaves.plant^{-1}) while the transaction (M0) gave the lowest value (22.7 leaves. plant^{-1}). As for the effect of plant density on the number of leaves, there was a moral effect, as the transaction of density (T3) gave the highest value of the number of leaves amounted to (27 leaves. plant^{-1}) which did not differ morally from the transaction (T2) and differed morally from the transaction (T1) which gave the lowest value to the number of leaves (25.8 leaves. plant^{-1}). The results of the same table show that the overlap between N-P-K fertilizer transactions and plant density transactions has a moral effect, with the interference transactions (M4 T2 and M4 T3) outperforming the high morale of Most of the interference transactions gave the highest value of the number of leaves (31 leaves. plant^{-1}) each while the interference transaction (M0 T2) gave the lowest value of (22 leaves. plant^{-1}).

3. Single leaf area (cm^2.Leaf^{-1})

The results in table (5) indicate the existence of a moral effect of the coefficients of fertilizer N-P-K in the area of the single leaf where the transaction (M4) gave the highest moral value of the area of a single leaf amounted to (661 cm^2. leaf^{-1}) and gave the transaction (M0) the lowest value for the area of one leaf amounted to (522 cm^2. leaf^{-1}). The effect of plant density indicates that there is no moral effect in the area of a single leaf. The results in the same table indicate that the effect of interference between N-P-K fertilizer coefficients and plant density transaction was not moral in the area of a single leaf.

Table 2 : The effect of the type of fertilizer and plant density and the overlap between them in the height of the plant (cm).

Average plant density	NPK fertilizer treatments					Plant density coefficients
	M 4	M 3	M 2	M 1	M 0	
69.2 B	71 ab	71 ab	72 ab	67 b	65 c	T 1
73.4 AB	78 ab	76 ab	75 ab	68 b	70 ab	T 2
75.8 A**	83 a**	76 ab	77 ab	75 ab	68 b	T 3
	77.3 A**	74.3 AB**	74.7 AB**	70 BC	67.7 C	Average fertilizer coefficients

The different letters mean that there are significant differences between the averages, according to Tukey's test.
Capital letters indicate the effect of the main factors and lowercase letters indicate the effect of the overlap.
**.There were significant coefficients at $P \leq 0.01$ in the ANOVA table.

Table 3 : The effect of the type of fertilizer and plant density and the overlap between them in the number of leaves (leaf. plant^{-1}).

Average plant density	NPK fertilizer treatments					Plant density coefficients
	M 4	M 3	M 2	M 1	M 0	
25.8 B	29 ab **	27 bc **	26 bcd**	24 bcd **	23 de	T 1
26.4 AB	31 a **	27 bc **	26 bcd **	26 bcd **	22 e	T 2
27.0 A *	31 a **	28 ab **	26 bcd **	27 bc **	23 de	T 3
	30.3 A **	27.3 B **	26.0 BC **	25.7 CD	22.7 D	Average fertilizer coefficients

The different letters mean that there are significant differences between the averages, according to Tukey's test.
Capital letters indicate the effect of the main factors and lowercase letters indicate the effect of the overlap.
**There were significant coefficients at $P \leq 0.01$ in the ANOVA table.
*There were significant coefficients at $P \leq 0.05$ in the ANOVA table.

Table 4 : The effect of the type of fertilizer and plant density and the overlap between them in the area of one leaf (cm^2.leaf^{-1}).

Average plant density	NPK fertilizer treatments					Plant density coefficients
	M 4	M 3	M 2	M 1	M 0	
540 A	647 a	552 a	507 a	494 a	501 a	T 1
577 A	667 a	600 a	571 a	511 a	535 a	T 2
597 A	670 a	608 a	602 a	573 a	530 a	T 3
	661 A*	587 AB	560 AB	526 B	522 B	Average fertilizer coefficients

The different letters mean that there are significant differences between the averages, according to Tukey's test.
Capital letters indicate the effect of the main factors and lowercase letters indicate the effect of the overlap.
*There were significant coefficients at $P \leq 0.05$ in the ANOVA table.

The results of the tables (4-3-2) obtained show that N-P-K fertilizer has a moral effect on the characteristics of vegetative growth and this effect is attributed to several reasons, the most important of which is because N-P-K fertilizer contains essential elements of plant growth, which have a role Effective and major in the vital processes that take place within the plant where the element of nitrogen enters the synthesis of proteins and nuclear acids (DNA and RNA) and has an important role in the division and elongation of cells as nitrogen enters the construction of the basic chlorophyll in the process of photosynthesis and breathing And other important processes (Abu Dahi and Younis, 1988), nitrogen nutrition increases the rate of plant growth and regulates the action of plant hormones (oxinate and cytokines) which increase the division of marsestemic cells, which is positively reflected in the increase of the vegetative total. The root sum that is essential for the plant is to absorb water and nutrients from the soil and transport them to be represented, including calcium, phosphorus and potassium (Hocking and Steer, 1982), phosphorus, which is one of the components of n-P-K fertilizer, has an important role in increasing Green and root branches have an important role in storing energy and converting it to (ATP and ADP) as well as an important role in analyzing carbohydrates and materials resulting from the photosynthesis process and freeing the energy needed by the plant for construction processes as well as it's role in the formation of cellular membranes and phosphorus is important in the process of cell division and the transfer of genetic traits being a component of nuclear acids (DNA and RNA) and phospholipids (Nell, 2009 and Blevian, 2001), potassium Which is one of the components of N-P-K fertilizer also contributed to the increase of the indicators of vegetative and radical growth through its role in the work of enzymes responsible for the synthetic construction of cells that enter the structure of the plant structure and potassium has an important role in the hormonal balance as well as increasing the efficiency of the work of growth organizations Plant, which increases the vegetative and radical growth of the plant as it has an important role in the speed of cell division and increase dizing, as well as an important role in improving the efficiency of carbon representation and thus the increase in the manufacture of nutrients necessary for plant growth (IPI, 2001) and these results are consistent with what he found (Chand *et al.*, 2017, Srichandan, others, 2015, Singh *et al.*, 2015).

There was a moral increase in the qualities of vegetative growth when increasing the distances of agriculture between plants and these qualities are the height of the plant table (2) and the number of leaf table (3) as a result of the increase of water and nutrients available to the plant and the lack of competition between plants for water and nutrients as well as obtaining and exposure to the largest amount of light falling on the plant and thus an increase in the outputs of the photosynthesis process, which reflects positively on these qualities (Alwan *et al.*, 2004) and this is consistent with what found (Sharif, 2008 and Roni *et al.*, 2017. and Malviya, 2017 and Thirupal *et al.*, 2014).

The main characteristics of the flowery discs:

1-Diagonal of the main flowery disc (CM)

The results in table (5) indicate that there is a moral effect of the compost transaction in the diagonal of the main

flowery disk where the transactio of manure (M4) exceeded the high moral superiority of all other compost transactions and gave the highest value of (23.7 cm) while the transaction (M0) gave the lowest value (17.3 cm). As for the effect of plant density in the diagonal of the main flowery disc, there is a moral effect where the plants (T2 and T3) exceeded the highest value (20.6 cm) while the transaction (T1) gave the lowest value (19 cm). The overlap between N-P-K and plant density transactions had a moral effect, outstripping the interference transaction (M4 T3) .High morale over most interference transactions gave the highest value of (25 cm) while the interference transaction (M0 T3 and M0 T1) gave the lowest value (17 cm) per transaction.

2-Weight of the main flowery disc (g):

The results in table (6) indicate that there is a moral effect of compost transaction in the weight of the main flowery disc where the transaction (M4) exceeded the high moral superiority of all other compost transactions except the transaction (M3) and gave the highest value (596 g) while the transaction (M0) gave the lowest value (400 g). In the same table, the results indicate a moral effect of the plant density transaction in the weight of the main flowery disc, where the transaction (T3) outperformed the moral superiority of other transactions and gave the highest value of (567 g) while the transaction (T1) gave the lowest value (406 g). The overlap between N-P-K fertilizer transactions and plant density transactions had a moral effect, with the m4 T3 overtaking the highest morale over most interference transactions and giving the highest value of (747 g) while the interference transaction (M0 T1) gave the lowest value (380 g).

3-The total product of the main flowery discs (ton. ha $^{-1}$).

The results in table (7) showed that there is a moral effect of the n-P-K fertilizer coefficients in the total yield of the main pink discs per hectare where the treatment (M4) exceeded the high moral ity of other fertilizer transactions except the treatment of M3 and gave the highest value (19.87 tons.ha^{-1}) while the treatment of fertilizer (M0) gave the lowest value (13.85 tons. ha^{-1}). In the same table, the results indicate a moral effect of plant density transactions in the total yield of the main flowery discs per hectare where the transaction (T1) exceeded the transaction (T1) and gave the highest value (18.04 tons.ha-1) while the transaction (T3) gave the lowest value (15.13 tons.ha-^{1}).The overlap between N-P-K fertilizer transactions and plant density transactions had a moral effect, with the M4 T3 and M4 T2 transactions outperforming the high moral superiority to give them the highest value (19.92 and 19.90 tons.ha^{-1}), respectively, while the intervention transaction (M0 T3) gave the lowest value (11.00 tons. ha^{-1}).

Table 5 : Impact of fertilizer type, plant density and overlap in the diagonal of the main flowery disc (CM)

Average plant density	NPK fertilizer treatments					Plant density coefficients
	M 4	M 3	M 2	M 1	M 0	
19.0 B	22 abc**	19 cde	19 cde	18 de	17 e	T 1
20.6 A**	24 ab**	21 bcd**	21 bcd**	19 cde	18 de	T 2
20.6 A**	25 a**	21 bcd**	21 bcd**	19 cde	17 e	T 3
	23.7 A**	20.3 B**	20.3 B**	18.7 C	17.3 C	Average fertilizer coefficients

The different letters mean that there are significant differences between the averages, according to Tukey's test.
Capital letters indicate the effect of the main factors and lowercase letters indicate the effect of the overlap.
**There were significant coefficients at $P \leq 0.01$ in the ANOVA table.

Table 6 : The effect of the type of fertilizer and plant density and the overlap between them in the weight of the main flowery disc (g).

Average plant density	NPK fertilizer treatments					Plant density coefficients
	M 4	M 3	M 2	M 1	M 0	
18.04 A**	19.78 ab**	18.89 ab**	17.11 abc	17.55 ab**	16.88 abc	T 1
16.32 AB	19.90 a**	18.8 ab**	15.9 abc	13.33 bc	13.67 abc	T 2
15.13 B	19.92 a**	15.74 abc	15.23 abc	13.78 abc	11.00 c	T 3
	19.87 A**	17.81 AB**	16.08 BC	14.89 BC	13.85 C	Average fertilizer coefficients

The different letters mean that there are significant differences between the averages, according to Tukey's test.
Capital letters indicate the effect of the main factors and lowercase letters indicate the effect of the overlap.
**There were significant coefficients at $P \leq 0.01$ in the ANOVA table.

Table 7 : The effect of the type of fertilizer and plant density and the overlap between them in the total main flowery discs (ton.ha^{-1}).

Average plant density	NPK fertilizer treatments					Plant density coefficients
	M 4	M 3	M 2	M 1	M 0	
406 C	445 bcde	425 bcde	385 e	395 de	380 e	T 1
490 B**	597 ab**	564 bcd**	477 bcde	400 cde	410 cde	T 2
567 A**	747 a**	590 ab**	571 bc**	517 bcde	411 cde	T 3
	596 A**	526 AB**	478 BC	437 CB	400 C	Average fertilizer coefficients

The different letters mean that there are significant differences between the averages, according to Tukey's test.
Capital letters indicate the effect of the main factors and lowercase letters indicate the effect of the overlap.
**There were significant coefficients at $P \leq 0.01$ in the ANOVA table.

The tables (7-6-5) show that the addition of N-P-K fertilizer to the soil has achieved a moral increase in most of the characteristics of the main flowery discs due to the rapid decomposition and spread of N-P-K fertilizer, which increases the Availability and readiness for absorption by plant (Al-Zahawi, 2017), as N-P-K fertilizer transactions have increased the qualities of vegetative growth all these qualities have increased the efficiency of photosynthesis and food processing as well as stimulating the process of transporting processed foods. From the places of manufacture to the places of storage, which resulted in an increase in the qualities of the crop (Abdi and Hedayat,2010), which reflected positively on the digonal of the main flowery disc Table (5), the weight of the main flowery disc Table (6) and the product of the total main flowery discs in the hectare table (7) and these results are consistent with the findings (Singh *et al.*, 2015 and Srichandan *et al.*, 2015 and Chand *et al.*, 2017).

The increase in the diagonal of the main flowery disc table (5) and the weight of the main flowery disc table (6) as a result of the increase in the distances of agriculture between plants is due to the extent that the divergent plants get the largest amount of light falling and reflected on the plant and nutrients ready to absorb in the soil and water and the lack of competition for these materials between plants, which led to an increase in the process of photosynthesis and accumulation of food in the main flowery disc and these results are consistent with the findings (Dev, 2012 and Hussain *et al.*, 2012 and Roni *et al.*, 2017 and Malviya, 2017).

The increase in the total yield of major flowery discs per hectare (with reduced farming distances is due to an increase in the number of plants planted in the area unit and thus an increase in the number of major flowery discs that give more and this is consistent with the findings of (Gogoi *et al.*, 2016 and Roni *et al.*, 2017 and Malviya, 2017).

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