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RESEARCH PAPER

HORTICULTURAL STUDIES

Effects of Potassium Applications on Growth, Tuber Yield, and Quality Parameters of Kohlrabi (*Brassica oleracea* var. gongylodes)

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Abstract

Potassium plays an important role in plant growth, assimilate transport, yield formation, and quality development in vegetable crops. Therefore, determining an appropriate potassium fertilization rate is important for improving the productivity and quality of kohlrabi. This study evaluated the effects of different potassium rates on the growth, yield, and quality characteristics of the Korist F_1 kohlrabi cultivar grown under unheated greenhouse conditions during the autumn–winter growing season in Korkuteli, Türkiye. The experiment was established according to a randomized complete block design with four potassium levels (Control, 100, 200, and 300 kg ha^{-1} K_2O) and four replications. Plant fresh weight, leaf number, and leaf fresh weight in kohlrabi increased substantially with potassium application compared to the control. The treatments of 200 and 300 kg ha^{-1} K_2O produced the largest total plant fresh yields, totaling 57.60 and 61.42 t ha^{-1}, respectively. The greatest increase in tuber fresh yield was obtained from the 300 kg ha^{-1} K_2O treatment, with a value of 31.91 t ha^{-1}, followed by the 200 kg ha^{-1} K_2O treatment, which resulted in a tuber fresh yield of 28.52 t ha^{-1}. The 200 kg ha^{-1} K_2O treatment demonstrated a beneficial impact on quality indicators, yielding the highest values for electrical conductivity and soluble solids content. Potassium fertilization significantly enhanced growth, production, and quality characteristics in kohlrabi, with 200–300 kg ha^{-1} K_2O being ideal for yield, but 200 kg ha^{-1} K_2O was more advantageous for quality attributes.

1. Introduction

Kohlrabi (*Brassica oleracea* var. gongylodes L.), belonging to the *Brassicaceae* family, is a vegetable with a short growing season that can adapt to different climatic conditions but is particularly well-suited for cultivation in cool climates. The stem of the plant has a swollen, fleshy structure. The stem can be green, white, or purple, but the flesh is white. The leaves and stem can be consumed raw or cooked. Due to its high fiber and low-fat content, the plant is a nutritious dietary vegetable (Sassi et al., 2020). Kohlrabi is also a highly nutritious vegetable, rich in antioxidants, phenolic and flavonoid compounds, antibacterial properties (Sassi et al., 2020), and minerals such as potassium, sodium, magnesium, zinc, and iron, as well as vitamins (Rizwan and Masoodi, 2025).

In Türkiye, the most commonly cultivated vegetables belonging to the *Brassicaceae* family are cabbage, broccoli, cauliflower, and radish, accounting for 61%, 18%, 9%, and 12% of total production, respectively (TÜİK, 2026). However, changing market and consumer demands have led producers to explore new plant varieties beyond traditional products. With the changes that have

taken place recently, the production of vegetable species belonging to the Brassicaceae family, such as curly kale, Chinese cabbage, and kohlrabi, has begun, albeit on a limited basis, and these products have started to appear not only in supermarkets but also in local markets.

Some studies conducted in Türkiye on kohlrabi have shown that factors such as planting time (Özer et al., 2015), growing medium (Kurtar et al., 2010), variety selection (Arın, 2002), irrigation level (Ulukapı and Kacar, 2020), and different fertilizer applications (Aydın et al., 2021) affect kohlrabi development and yield. Furthermore, kohlrabi is considered a crop with a relatively high potassium requirement. Positive responses of kohlrabi to potassium-containing fertilization programs have been reported by Al-Mharib et al. (2020) and Roy et al. (2018). Al-Mharib et al. (2020) found that a fertilization program containing 120 kg ha^{-1} K_2O improved growth and yield, whereas Roy et al. (2018) obtained the highest marketable yield with 249 kg ha^{-1} K applied as part of a combined NPK, Zn, B fertilization program.

One of the key factors affecting growth and tuber yield in kohlrabi is correct and balanced fertilizer application. Potassium fertilizers are among the most widely used nutrient sources for improving yield and quality. Research on *Brassica* species has demonstrated that potassium enhances photosynthetic capacity (Hu et al., 2023), promotes plant growth and biomass accumulation (Yan et al., 2023), and contributes to yield formation. In contrast, potassium deficiency reduces nutrient uptake, alters primary metabolism and hormonal balance, and ultimately restricts plant growth and productivity (Réthoré et al., 2021). In Mediterranean regions, vegetable production is commonly conducted on calcareous soils characterized by high pH and high calcium carbonate. Under such conditions, determining appropriate potassium fertilization strategies is important for optimizing crop productivity and quality. Studies on kohlrabi have mainly focused on NPK fertilization programs and mineral–organic fertilizer combinations (Al-Azzawi and Ghassan, 2024; Ghalib and Ghassan, 2023), whereas information on crop responses to independently applied K_2O rates remains limited.

The high altitude of Korkuteli and the low temperatures prevailing from November to March restrict vegetable production even under greenhouse conditions and shorten the growing season. This study evaluated the effects of different K_2O doses on the growth, yield, and quality characteristics of the Korist F_1 kohlrabi cultivar and identified the optimum potassium application rate for improving production performance under high-altitude greenhouse conditions.

2. Material and Methods

In this study, the widely cultivated white kohlrabi cultivar 'Korist F_1' was used as the plant material. The cultivation phase of the experiment was conducted during the autumn–winter growing season, from 6 November 2024 to 20 February 2025, in an unheated plastic greenhouse located in Korkuteli, Antalya, Türkiye. Before the establishment of the experiment, soil samples were collected from 10 points within the experimental area at a depth of 0–30 cm following a zigzag sampling pattern. The samples were composited, homogenized, and analyzed to determine the physical and chemical properties of the soil. The results of the soil analyses are presented in Table 1. The experiment was conducted in a total area of 100 m², and plants were transplanted at a spacing of 40 cm between rows and 30 cm within rows.

The experiment was conducted according to a randomized complete block design with four treatments (Control, 100, 200, and 300 kg ha^{-1} K_2O, equivalent to 83, 166, and 249 kg ha^{-1} K) and four replications. Potassium sulfate (50% K_2O) was used as the source of potassium. Based on the soil analysis conducted prior to planting, a moderate basal fertilization of 80 kg ha^{-1} compound fertilizer (15–30–15, N–P_2O_5–K_2O) was applied to the experimental area. During the growing season,

Table 1. Physical and chemical properties of the experimental soil before planting.

Soil property	Value	Interpretation	Reference
Sand (%)	11.4	Heavy clay texture	(USDA, 2017)
Silt (%)	18.2		(USDA, 2017)
Clay (%)	70.4		(USDA, 2017)
pH	7.7	Slightly alkaline	(USDA, 2017)
EC (dS m^{-1})	1.3	Non-saline	(USDA, 2017)
$CaCO_3$ (%)	41.1	Very highly calcareous	(FAO, 2006)
Organic matter (%)	2.5	Low	(Havlin et al., 2017)
Total N (%)	0.13	Low	(Havlin et al., 2017)
Available P (mg kg^{-1})	33	Adequate	(Havlin et al., 2017)
Exchangeable K (mg kg^{-1})	524	High	(Marx et al., 1999)
Exchangeable Ca (mg kg^{-1})	5338	Very high	(Marx et al., 1999)
Exchangeable Mg (mg kg^{-1})	1404	High	(Marx et al., 1999)
Fe (mg kg^{-1})	10.8	Sufficient	(Havlin et al., 2017)
Mn (mg kg^{-1})	12.1	Sufficient	(Havlin et al., 2017)
Zn (mg kg^{-1})	3.4	Sufficient	(Havlin et al., 2017)
Cu (mg kg^{-1})	1.6	Sufficient	(Havlin et al., 2017)

nitrogen fertilization was applied at a total rate of 120 kg ha^{-1} N. Nitrogen applications were split into three doses: the first was applied before planting together with the basal fertilization, the second was applied two weeks after planting, and the third was applied at the beginning of tuber formation. Urea (46% N) was used as the nitrogen source in the second and third applications. Since soil analysis results indicated sufficient phosphorus content, no additional fertilizer was applied beyond the phosphorus already present in the base fertilizer. All plots were established with equal size, and nitrogen and phosphorus levels were kept constant across treatments. Potassium application rates were calculated by accounting for the K_2O supplied through the basal fertilizer. Potassium treatments were split into two applications, with half applied 12 days after transplanting and the remaining half applied at the beginning of tuber formation. Irrigation was applied uniformly to all treatments throughout the growing period based on soil moisture conditions, and plants were irrigated regularly to maintain optimal soil moisture and prevent water stress. Climatic data for the experimental area is given in Figure 1.

The electrical conductivity (EC) and pH of the soil samples collected prior to the experiment were determined in a 1:2.5 soil-to-water suspension according to the method described by Kacar (2016). Calcium carbonate ($CaCO_3$) content was determined using a Scheibler calcimeter (Kacar, 2016). Soil texture was determined by the Bouyoucos hydrometer method (Bouyoucos, 1951). Organic matter content was determined using the modified Walkley–Black method (Walkley and Black, 1934). Total nitrogen was determined using the Kjeldahl method described by Bremner (1965). The Olsen method (Olsen et al., 1954) was employed for determining available phosphorus. Exchangeable potassium (K), calcium (Ca), and magnesium (Mg) were quantified utilizing a 1 N extraction technique with ammonium acetate at pH 7.0 (Kacar, 2016). Available iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn) were determined using the DTPA extraction method (Lindsay and Norvell, 1978). A Jasco V-730 UV-visible spectrophotometer was used to determine the amount of available phosphorus in the soil, while a PG-990 atomic absorption spectrophotometer was used for the analysis of the elements K, Ca, Mg, Fe, Mn, Zn, and Cu.

Harvest was carried out when the plants reached marketable maturity, corresponding to a tuber diameter of approximately 70-100 mm. Plants were harvested manually by cutting at the base of the stem just below the swollen tuber under uniform conditions across all treatments. For each harvested plant, plant height (cm) was measured using a measuring tape. Tuber diameter (mm) was measured at the center of each tuber using a digital caliper, and tuber length (mm) was determined by measuring the distance from the lower to the upper end of the tuber. Some images of the post-harvest measurements and analyses are given in Figure 2.

Plant fresh weight (rootless, g $plant^{-1}$), tuber fresh weight (g $plant^{-1}$), and leaf fresh weight (g $plant^{-1}$) were recorded. Leaf samples were oven-dried at 65°C until constant weight, and leaf dry weight (g $plant^{-1}$) was determined using a balance with a sensitivity of 0.1 g. The number of leaves per plant was determined by manually counting leaves longer than 2.0 cm. The tuber ratio (tuber fresh weight plant fresh $weight^{-1}$), total plant fresh yield (t ha^{-1}), and tuber fresh yield (t ha^{-1}) were calculated. Flesh firmness was measured by slightly removing the outer peel of the tuber and inserting the 9.0 mm diameter probe of a hand penetrometer into the central portion of the tuber, and results were expressed as kg cm^{-2}. For quality analyses, tubers were processed using a juice extractor, and the extracted juice was filtered through coarse filter paper. The filtrate was used to determine soluble

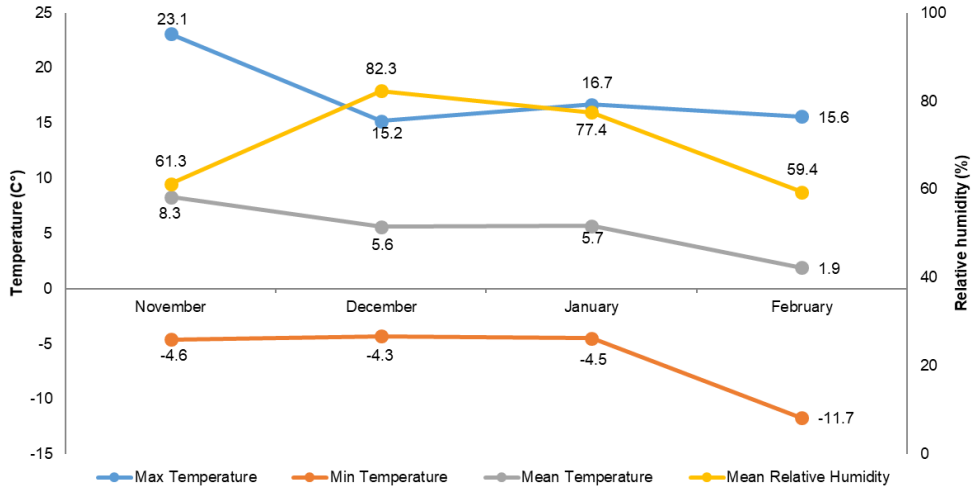


Figure 1. Monthly temperature and relative humidity variation in Korkuteli.



Figure 2. Morphological and quality analyses performed in kohlrabi (*Brassica oleracea* var. *gongylodes*): (A) measurement of flesh firmness; (B) tuber length; (C) comparison of tuber size; (D) preparation of samples for juice analysis; (E) fresh weight measurement; and (F) plant height and leaf characteristics.

Table 2. Effects of K_2O application rates on vegetative growth parameters of kohlrabi (*Brassica oleracea* var. *gongylodes*).

Treatments	Plant height (cm)	Plant fresh weight (g plant^{-1})	Leaf number (nr. plant^{-1})	Leaf fresh weight (g plant^{-1})	Leaf dry weight (g plant^{-1})
100 kg ha^{-1} K_2O	56.0[1]±4.6	610.12±36.20^{b}	23.75±1.44^{bc}	328.46±35.52^{a}	48.84±18.91
200 kg ha^{-1} K_2O	53.2±3.7	720.06±93.91^{a}	26.44±0.43^{a}	357.71±51.47^{a}	53.73±10.40
300 kg ha^{-1} K_2O	59.4±3.9	767.72±60.55^{a}	25.67±1.58^{ab}	363.46±57.46^{a}	55.76±9.29
Control	50.3±8.9	420.09±76.26^{c}	22.71±1.67^{c}	237.54±42.86^{b}	34.67±10.14
Significance	ns	p<0.01	p<0.01	p<0.05	ns

[1] Values are means of four replications ± standard deviation.
[a,b]: Different letters within the same column are significantly different. ns: not significant.

solids content (SSC, °Brix) using a digital refractometer, while pH and electrical conductivity (EC) were measured using a benchtop pH and EC meter.

Research data were analyzed using the licensed SPSS (2017) statistical package (SPSS Statistics Base v. 23) based on an experimental design. Data were analyzed using ANOVA, and significant differences were compared using Duncan's test.

3. Results and Discussion

3.1. Vegetative growth of plants

The effects of potassium applications on selected vegetative growth parameters of kohlrabi are presented in Table 2. Potassium applications did not create a statistically significant difference in plant height. Although the differences were not statistically significant, the highest plant height was recorded with 300 kg ha^{-1} K_2O (59.4 cm), whereas the lowest value was recorded in the control (50.3 cm). In contrast, plant fresh weight was significantly affected by potassium applications (P<0.01). The highest plant fresh weight was obtained at the 300 kg ha^{-1} K_2O dose (767.72 g), followed by the 200 kg ha^{-1} (720.06 g) and 100 kg ha^{-1} (610.12 g) K_2O treatments. The lowest plant fresh weight (420.09 g) was recorded in the control plots. The increase in biomass with potassium fertilization can be attributed to the role of potassium in regulating cell turgor, enhancing carbohydrate translocation, and promoting leaf area development, all of which collectively contribute to improved vegetative growth (Wang et al., 2013). Our study clearly demonstrates this situation, with increasing K doses showing a parallel increase in plant mass. Previous studies conducted on the Korist F1 cultivar have reported that plant weight can vary over a wide range and that this parameter is closely related to environmental conditions and the growing season. Özer et al. (2015) reported that plant weights in the Korist F_1 variety ranged from 311.17 to 838.33 g, while Kurtar et al. (2010) reported that they ranged from 181.90 to 492.33 g. These findings are consistent with the results of the present study.

In terms of leaf number, the 200 kg ha^{-1} K_2O treatment resulted in the highest value, with an average of 26.44 leaves per plant, whereas the control treatment exhibited the lowest value at

22.71 leaves (p<0.01). Özer et al. (2015) reported leaf numbers ranging from 13.44 to 20.08 leaves per plant, while Kurtar et al. (2010) reported values between 8.17 and 17.56 leaves per plant. Ulukapı and Kacar (2020) reported significantly lower values, ranging from 5 to 7 leaves per plant. Compared with these studies, the higher leaf number values obtained in the present study indicate that potassium applications significantly promoted leaf development in kohlrabi.

3.2. Tuber morphological characteristics and yield components

The effect of potassium applications on the morphological characteristics of kohlrabi tubers is presented in Table 3. The effects of the applications on tuber diameter, tuber length, and tuber fresh weight were found to be statistically significant. Among the treated plants, the highest tuber diameter (90.9 mm), tuber length (66.9 mm), and tuber fresh weight (398.82 g) were measured from the 300 kg ha^{-1} K_2O application (Table 3). In kohlrabi plants, tuber diameter ranged from 62.4 to 96.6 mm, tuber length from 46.8 to 72.4 mm, tuber fresh weight from 120.43 to 432.34 g, and tuber ratio from 0.38 to 0.57. Özer et al. (2015) reported that in the Korist F1 variety grown during the autumn season under Samsun conditions, tuber diameter ranged from 77.6 to 98.3 mm, tuber length from 59.1 to 88.0 mm, and tuber fresh weight from 242.92 to 580.28 g. Similarly, under spring growing conditions, Kurtar et al. (2010) reported tuber diameters ranging from 60.8 to 90.0 mm, tuber lengths from 72.2 to 83.2 mm, and tuber fresh weights from 83.90 to 379.89 g. These results are consistent with and support the findings of the present study.

Potassium applications significantly increased both total plant fresh yield and tuber fresh yield in kohlrabi, as illustrated in Figure 3. The highest total plant fresh yield (61.42 t ha^{-1}) was achieved with 300 kg ha^{-1} K_2O, followed by 200 kg ha^{-1} (57.60 t ha^{-1}) and 100 kg ha^{-1} (48.81 t ha^{-1}). The lowest total plant fresh yield was recorded in the control treatment at 33.61 t ha^{-1}. The tuber fresh yield of kohlrabi was highest at 31.91 t ha^{-1} with the application of 300 kg ha^{-1} K_2O. In the experiment, the total plant fresh yield varied between 25.55 and 68.04 t ha^{-1}, while the tuber fresh yield varied between 9.63 and 34.58 t ha^{-1}. The increase in yield in the study can be explained by potassium being a vital nutrient for plants, especially for maintaining water balance (Wang et al., 2013) and transporting carbohydrates from leaves to storage organs such as roots, tubers, and fruits (Marschner, 2012).

3.3. Quality parameters

The effects of potassium treatments on the quality attributes of kohlrabi are presented in Table 4. Potassium application had no statistically

Table 3. Changes in tuber morphological characteristics in kohlrabi plants depending on different K_2O applications.

Treatments	Tuber diameter (mm)	Tuber length (mm)	Tuber fresh weight (g plant^{-1})	Tuber ratio
100 kg ha^{-1} K_2O	83.0[1]±3.17[a]	61.1±7.15[ab]	278.45±22.56[b]	0.46±0.04
200 kg ha^{-1} K_2O	85.7±9.99[a]	61.9±5.23[ab]	356.55±68.91[a]	0.49±0.06
300 kg ha^{-1} K_2O	90.9±31.98[a]	66.9±4.40[a]	398.82±23.31[a]	0.52±0.04
Control	72.2±6.55[b]	53.5±5.21[b]	180.39±41.44[c]	0.43±0.05
Significance	p<0.01	p<0.05	p<0.01	ns

[1] Values are means of four replications ± standard deviation. [a,b]: Different letters within the same column are significantly different. ns: not significant.

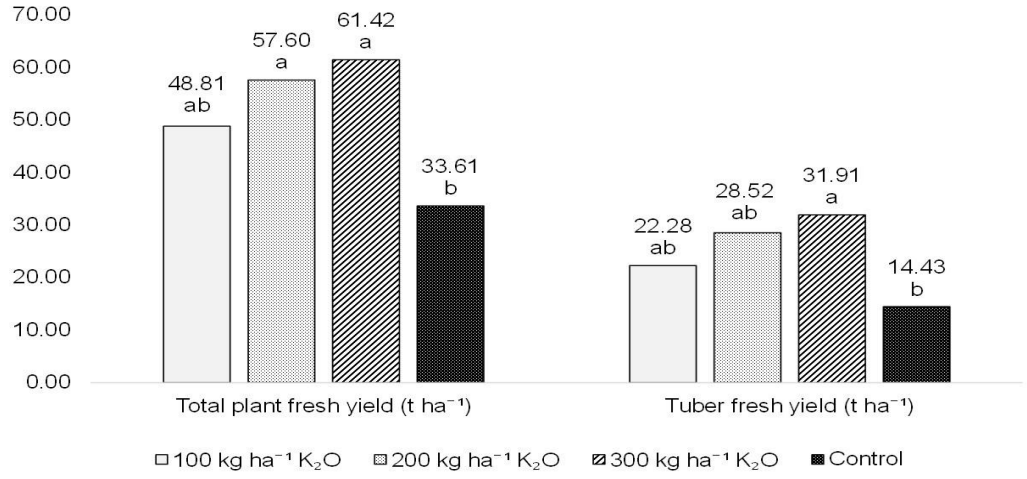


Figure 3. Total plant fresh yield (t ha^{-1}) and tuber fresh yield (t ha^{-1}) of kohlrabi as affected by different potassium application rates.

Table 4. Effects of different K_2O application rates on quality parameters of kohlrabi (*Brassica oleracea* var. *gongylodes*).

Treatments	Flesh firmness (kg cm^{-2})	pH	EC (mS cm^{-1})	Soluble solids content (Brix)
100 kg ha^{-1} K_2O	10.69[1]±1.75	6.42±0.17	6.74±1.79[b]	11.30±1.16[ab]
200 kg ha^{-1} K_2O	11.30±1.10	6.29±0.13	8.84±0.30[a]	12.23±1.14[a]
300 kg ha^{-1} K_2O	9.97±0.53	6.45±0.03	7.29±0.14[ab]	11.60±0.54[ab]
Control	9.95±0.70	6.50±0.04	6.56±1.04[b]	10.13±0.78[b]
Significance	ns	ns	p<0.05	p<0.05

[1] Values are means of four replications ± standard deviation. [a,b]: Different letters within the same column are significantly different. ns: not significant.

significant effect on flesh firmness. Flesh firmness values ranged from 8.14 to 12.77 kg cm^{-2}.

Tuber juice pH ranged from 6.19 to 6.63, and no statistically significant difference was observed between the applications. In contrast, the electrical conductivity (EC) values of the tuber juice differed significantly between the applications ($p<0.05$), with the highest EC values determined in the 200 kg ha^{-1} K_2O application. The increase in EC, an indicator of the dissolved mineral content in the tuber juice, can be explained by the central role of potassium in nutrient transport (Sardans and Peñuelas, 2021).

Potassium treatments also had a statistically significant effect on the soluble solids content (SSC) in the tuber juice ($p<0.05$), with the highest soluble solids value recorded at the 200 kg ha^{-1} K_2O. Given the regulatory role of potassium in carbohydrate metabolism and sugar translocation, this increase is an expected outcome. The soluble solids content of kohlrabi ranged from 9.20% to 13.80%, which is higher than the findings reported by Kurtar et al. (2010). This can be explained by the positive effect of potassium fertilization on sugar and soluble solids accumulation in the plants. The soluble solids values obtained in this study are consistent with previous reports indicating that fertilization practices involving potassium can influence quality parameters in tuber *Brassica* species (Khede et al., 2019; Shah et al., 2019).

4. Conclusions

Potassium fertilization significantly affected the growth, yield, and quality characteristics of Korist F_1 kohlrabi grown under autumn–winter greenhouse conditions. Increasing K_2O rates enhanced plant biomass accumulation, tuber development, and yield performance. The highest total plant fresh yield and tuber fresh yield were obtained with 300 kg ha^{-1} K_2O, while 200 kg ha^{-1} K_2O resulted in the highest soluble solids content and electrical conductivity values. Although the 300 kg ha^{-1} K_2O treatment produced the highest yields, its advantage over the 200 kg ha^{-1} K_2O treatment was limited. Considering both agronomic performance and quality attributes, 200 kg ha^{-1} K_2O was identified as the most suitable application rate under the tested autumn–winter greenhouse conditions. These findings indicate that potassium management is an important factor for improving kohlrabi productivity during the autumn–winter growing season in high-altitude Mediterranean regions.

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