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# Effect of Drought Stress on Seedling Morphological Traits of Four Commercial Hybrids of Egyptian Watermelon

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**ABSTRACT: A major significant barrier to watermelon cultivation is drought stress conditions. In this investigation estimated morphological traits of seedling plants were subjected in artificial drought stress scheme in order to categorize four commercial hybrids of Egyptian watermelon (Aswan, Giza-1, Fagr-101 and Sina) under normal (100% water) and drought stress (50% water) conditions as tolerant versus susceptible. Each treatment was repeated three times in randomized complete blocks design (RCBD). The studied hybrids were planted in pots under greenhouse conditions to allow grow until true three leaf stage. After that, the studied treatments were initiated for 45 days. Differences under normal and drought stress conditions had been computed for each estimated trait. According to finding, there was direct decrease in estimated morphological traits under drought stress conditions as compared to normal conditions. Furthermore, under normal conditions, there was significant correlation (0.904*) between seedling length and shoot fresh weight. In contrast, under drought stress conditions, there were highly significant negative correlation between shoot fresh weight and root dry weight, and significant positive (0.952*) between leaves number per seedling and root fresh weight. Additionally, Clusters showed that, hybrids Aswan and Fagr-101 performed well under normal and drought stress conditions, respectively. While, hybrid Giza-1 performed best under both conditions. Based on finding, tolerant cultivars can be useful as a parental material in future breeding programs. Furthermore, estimated morphological traits may be useful in trends of plant responses to drought stress during watermelon cultivation or any other crop.**

**Keywords:** Egyptian watermelon hybrids, seedling morphological traits, normal conditions, drought stress conditions.

## INTRODUCTION

The watermelon or *Citrullus lanatus*, is a member of the genus Citrullus, kingdom Plantae, order Cucurbitales, and family Cucurbitaceae (Khandaker *et al.*, 2020), having 22 chromosomes in total (Meshram *et al.*, 2020; Carla *et al.*, 2022). It grows as a staple food (Ribeiro *et al.*, 2021; Ebadi *et al*., 2022; Nabwire *et al.*, 2022), because it contains amounts of protein, fat, minerals, and vitamins, and 93% water as well (Mihail and Amnon 2018; Wehner *et al.*, 2020; Nabwire *et al.*, 2022). It is therefore considering one of the most economically significant vegetable crops worldwide.

It is believed that seedlings are more vulnerable to drought stress. In order to reduce water loss and survive during drought stress, plants have evolved variety of mechanisms including drought escape, drought avoidance and drought tolerance stress (Shin *et al.*, 2021; Madumane *et al.*, 2024). Drought is a abiotic stress that limits the production of all the crops, which affects growth, development and yield of rice (Nandhitha *et al.*, 2022). So, a precise and consistent method for achieving drought tolerance is necessary for plants under drought stress throughout seedling growth (Mihail and Amnon 2018; Giordano *et al.*, 2021). Thus, drought tolerance has been determined by comparing seedling that are reacted to different levels of drought stress because the water potential between the seeds and substrates has decreased due to the reduction in the flow of water and nutrients from soil (Mohamed *et al*., 2021; Sewelo *et al.*, 2024), by attributing negative changes in transpiration rate, translocation, stomatal conductance, and leaf-relative water content to net assimilation (Pereira *et al.*, 2020; Bashir *et al*., 2021). Therefore, to survive seedlings under drought stress, plants maintain their water status and homeostasis. Hence, the purpose of this study was to evaluate drought tolerance of seedlings four commercial hybrids of Egyptian watermelon under both normal (100% water) and drought stress conditions (50% water).

## MATERIALS AND METHODS

The current study was examined drought tolerance of seedlings four commercial hybrids of Egyptian watermelon (Aswan, Giza-1, Fagr-101 and Sina) in a greenhouse at faculty of agriculture, Sohag university experimental farm, which located in Elkawamel, Sohag, Egypt throughout summer season 2022. Two water treatments normal (100% water) and drought stress (50% water) were applied in randomized complete block design (RCBD) with three repetitions.

Twenty seeds were submerged in water for 15 minutes and stored at room temperature after blotting for four hours. The seeds were then sterilized for 30 seconds with 70% ethanol and rinsed five times in sterilized distilled water. After that, seeds were germinated in incubator at 37°C for one week. Next, five uniform and healthy seedlings in each hybrid were chosen and transferred into plastic pots filled with soil. Following transplanting, seedling received daily irrigation to keep moisture in soil until reached three true leaf stage. For 45 days, treatments of normal and drought stress conditions were applied by (100% water) and (50% water), respectively, for all studied hybrids. The following six morphological traits were noted in random ten seedlings:

1. Seedling Length (cm), were taken by measuring main stem of seedling by rubber.
2. Leaves Number per Seedling, were taken by counting all leaves per seedling.
3. Shoot Fresh Weight (gm), were taken by weight fresh shoots by electron balance.
4. Shoot Dry Weight (gm), were taken by weighting dry shoots (dried in oven at 60℃ for 24 hours).
5. Root Fresh Weight (gm), were taken by weighting fresh roots by electron balance.
6. Root Dry Weight (gm), were taken by weighting dry roots (dried in oven at 60℃ for 24 hours).

Statistical analysis was performed with the aid of SPSS (version 22), NCSS24 and Past-3 statistical software's.

## RESULTS

Plants are subjected to a variety of abiotic stress factors that impact their ability to thrive throughout their life cycle. Drought stress is one of these stresses that affects plant morphology, because it limits the amount of water in soil. Consequently, we cultivated four commercial Egyptian hybrids of watermelon under two distinct water treatments: normal (100% water) and drought stress (50% water) to summarize and outline the impact of drought stress on their growth initiated at three true leaf stage, due to their diverse on genetic backgrounds which are linked to various performances in drought stress tolerant that explain varieties effects on its seedling growth.

The finding demonstrated that, there was genetic variability among the studied hybrids under both conditions as mentioned in Table 1, 2, that noted descriptive analysis of estimated morphological traits concerning studied hybrids. According to mean ± S.E. (Fig. 1) of estimated morphological traits of the studied hybrids, the hybrids Giza-1, Aswan, Fagr-101 and Sina as well as Fagr-101, Giza-1, Aswan and Sina noted highest values in respective for seedling length and leaves number per seedling, respectively. In the meantime, the greatest amount for shoot fresh and dry weight and root fresh weights under both conditions were noticed in respective in Giza-1, Aswan, Fagr-101 and Sina, and Giza-1, Aswan, Sina and Fagr-101, respectively. In contrast, Fagr-101, Giza-1, Aswan and Sina showed in respective largest values in root fresh and dry weights under drought stress conditions, suggesting that plant roots are the first experience to drought stress, due to it direct contact to water and nutrient. However, under normal conditions, the respective highest values for root dry weight were obtained in Aswan, Fagr-101, Giza-1 and Sina, referring that roots are initiators of signal transduction pathways connected to processes of drought response. Indicating vigorous and active root system may have resulted in high performance in shoot and root fresh weight, which increased leaf area formation for photosynthetic activity that led to increase, plant cell divisions. Furthermore, stronger shoot and root development aided in water intake which may be results accumulation of its dry matters or biomass. All o theses distinctly shoed that, good root formation especially at seedling growth stage are extremely important in drought tolerance of watermelon plants.

Pearson correlation analysis under both conditions were done between studied traits to show direction between them as mentioned in Table 3, 4 and Fig. 2. Under normal conditions, the results noticed significant positive correlation (0.904*) between seedling length and shoot fresh weight, encouraging selection these traits because increase in seedling length led to increase in shoot fresh weight. However, when drought stress was presented, leaves number per seedling and root fresh weight had significant positive correlation (0.952*), referring that selection for these traits emphasized by pointing out highest values between each other. Conversely, there was highly significant negative correlation (-0.996**) between shoot fresh weight and root dry weight, demonstrating that rise in shoot fresh weight was accompanied by fall in root dry weight, pointing to possibility that drought stress may prevent plant cell division, cell expansion and morphogenesis.

In order to assess the contribution of the estimated traits, similarity index between the studied hybrids and estimated traits was calculated by Euclidian heatmap double dendrogram cluster analysis as showed in Tables 5, 6 and Fig. 3. Under normal conditions, there are two clusters: cluster-1, includes seedling length and shoot fresh weight, while cluster-2, involved leaves number per seedling, shoot dry weight, root fresh weight and root dry weight. In addition, Aswan and Giza-1 grouped in cluster-1, whereas, Fagr-101 and Sina didn't belong to any cluster. Contrarily, under drought stress conditions, seedling length wasn't included in any cluster, while, shoot dry weight, root fresh and dry weights were grouped in cluster-1. However, leaves number per seedling and shoot fresh weight were grouped in cluster-2. Moreover, Giza-1 and Fagr-101 were included in cluster-1 compared to Aswan and Sina that weren't inserted in any cluster, demonstrating that, the studied hybrids were performed differentially on traits under both normal and drought stress conditions.

Based on the obtained data, one-way phylogenetic tree (Fig. 4) was constructed to verify and confirm the final performance of the studied hybrids toward estimated morphological traits. Under normal conditions, Giza-1 and Aswan formed single group compared to others. In contrast, Giza-1 and Fagr-101 cluster together compared to others when drought stress presented. Implying that the hybrids in the same group performed similarly rather than others.

Specifically, under both conditions, Giza-1 were performed best, while Aswan and Fagr-101 were performed well following Giza-1, otherwise Sina were performed low.

**Table 1: Minimum, maximum, mean, standard deviation, and variance of the estimated morphological traits under normal conditions.**

| | Minimum | Maximum | Mean | Std. Deviation | Variance |
|---|---|---|---|---|---|
| **Seedling Length** | 11.00 | 18.00 | 14.75 | 2.99 | 8.92 |
| **Leaves Number per Seedling** | 4.00 | 7.00 | 5.50 | 1.29 | 1.67 |
| **Shoot Fresh Weight** | 10.00 | 12.00 | 10.75 | 0.96 | 0.92 |
| **Shoot Dry Weight** | 0.83 | 1.00 | 0.92 | 0.09 | 0.01 |
| **Root Fresh Weight** | 2.36 | 3.00 | 2.65 | 0.27 | 0.07 |
| **Root Dry Weight** | 0.15 | 0.20 | 0.17 | 0.03 | 0.001 |

**Table 2: Minimum, maximum, mean, standard deviation, and variance of the estimated morphological traits under drought stress conditions.**

| | Minimum | Maximum | Mean | Std. Deviation | Variance |
|---|---|---|---|---|---|
| **Seedling Length** | 10.00 | 15.00 | 13.00 | 2.16 | 4.67 |
| **Leaves Number per Seedling** | 4.00 | 6.00 | 5.00 | 0.817 | 0.67 |
| **Shoot Fresh Weight** | 6.00 | 8.00 | 7.25 | 0.96 | 0.92 |
| **Shoot Dry Weight** | 0.61 | 0.75 | 0.67 | 0.06 | 0.004 |
| **Root Fresh Weight** | 1.90 | 2.32 | 2.08 | 0.18 | 0.032 |
| **Root Dry Weight** | 0.11 | 0.21 | 0.15 | 0.05 | 0.002 |

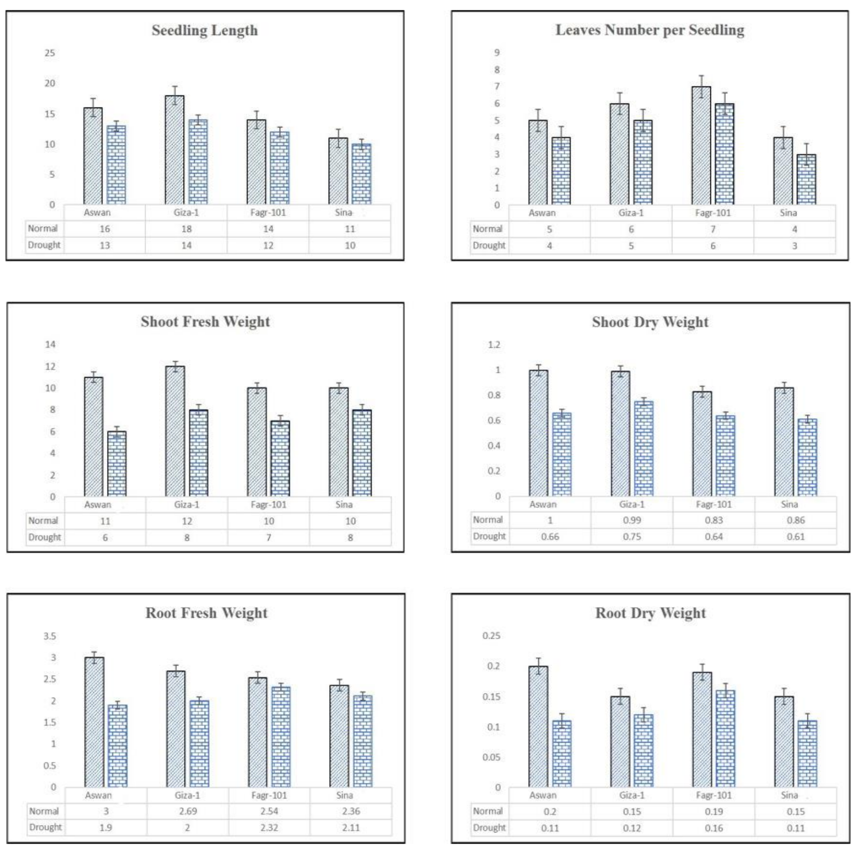


**Fig. 1.** Estimated morphological traits (Mean ± S.E.) of four commercial hybrids of Egyptian watermelon seedlings under normal (100% water) and drought stress (50% water).

**Table 3: Pearson correlation coefficient between estimated morphological traits under normal conditions.**

| | Seedling Length | Leaves Number per Seedling | Shoot Fresh Weight | Shoot Dry Weight | Root Fresh Weight | Root Dry Weight |
|---|---|---|---|---|---|---|
| **Seedling Length** | 1 | | | | | |
| **Leaves Number per Seedling** | 0.476 | 1 | | | | |
| **Shoot Fresh Weight** | **0.904*** | 0.135 | 1 | | | |
| **Shoot Dry Weight** | 0.79 | -0.147 | 0.875 | 1 | | |
| **Root Fresh Weight** | 0.716 | 0.11 | 0.562 | 0.816 | 1 | |
| **Root Dry Weight** | 0.138 | 0.344 | -0.232 | 0.058 | 0.623 | 1 |

**Table 4: Pearson correlation coefficient between estimated morphological traits under drought stress conditions.**

| | Seedling Length | Leaves Number per Seedling | Shoot Fresh Weight | Shoot Dry Weight | Root Fresh Weight | Root Dry Weight |
|---|---|---|---|---|---|---|
| **Seedling Length** | 1 | | | | | |
| **Leaves Number per Seedling** | 0.378 | 1 | | | | |
| **Shoot Fresh Weight** | -0.322 | 0.426 | 1 | | | |
| **Shoot Dry Weight** | 0.512 | -0.136 | 0.202 | 1 | | |
| **Root Fresh Weight** | 0.266 | **0.952*** | 0.247 | -0.416 | 1 | |
| **Root Dry Weight** | 0.373 | -0.449 | **-0.996**** | -0.11 | -0.293 | 1 |

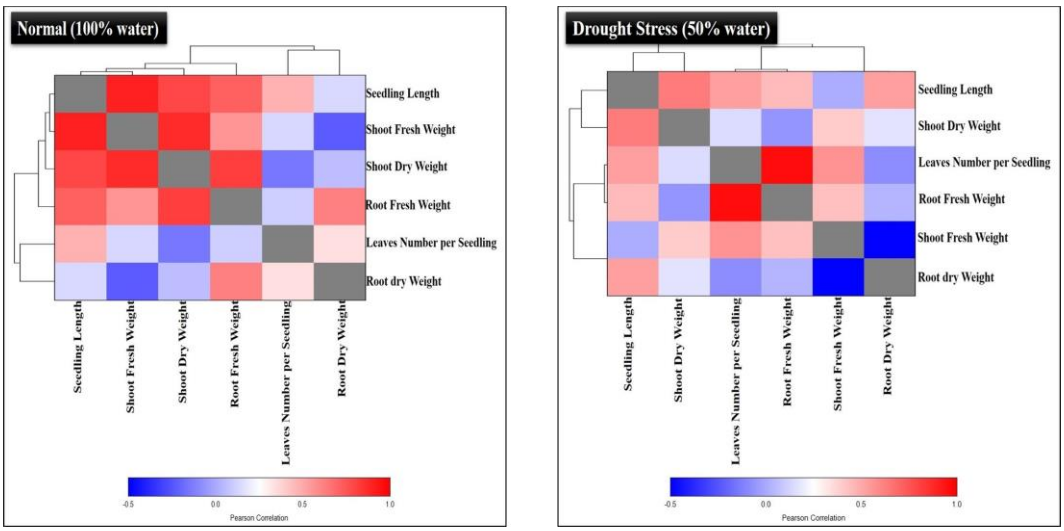


**Fig. 2.** Double dendrogram heatmap cluster analysis of Pearson correlation based on UPGMA of the estimated morphological traits under normal and drought conditions.

**Table 5: Cluster analysis of hybrids and estimated morphological traits under normal conditions.**

| **Cluster** | **Traits** |
|---|---|
| 1 | Seedling Length and Shoot Fresh Weight |
| 2 | Leaves Number per Seedling, Shoot Dry Weight, Root Fresh Weight and Root dry Weight |
| **Cluster** | **Four commercial hybrids of Egyptian watermelon** |
| 1 | Aswan and Giza-1 |
| None | Fagr-101 and Sina |

**Table 6: Cluster analysis of hybrids and estimated morphological traits under drought stress conditions.**

| **Cluster** | **Traits** |
|---|---|
| 1 | Shoot Dry Weight, Root Fresh Weight and Root dry Weight |
| 2 | Leaves Number per Seedling and Shoot Fresh Weight |
| None | Seedling Length |
| **Cluster** | **Four commercial hybrids of Egyptian watermelon** |
| 1 | Giza-1 and Fagr-101 |
| None | Aswan and Sina |

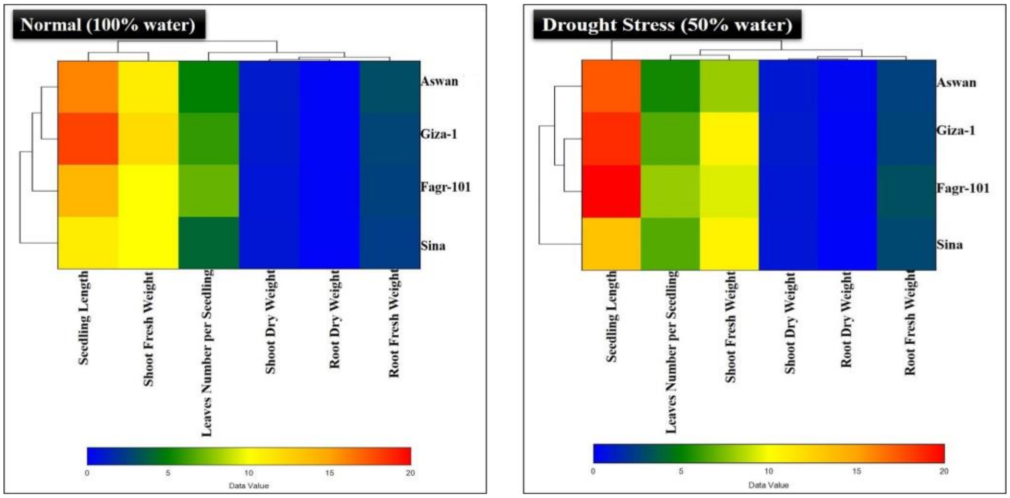


**Fig. 3.** Comparing the examined hybrids and estimated morphological traits under normal and drought stress conditions using Euclidean heatmap double dendrogram cluster analysis based on UPGMA.

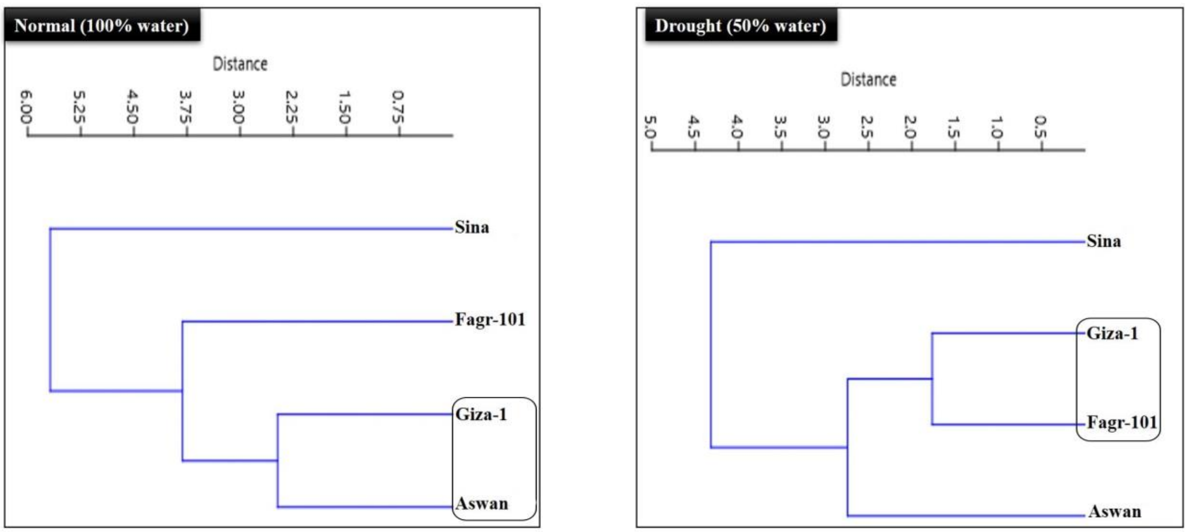


**Fig. 4.** The Euclidean similarity index used to estimate one-way phylogenetic tree between the studied hybrids under normal and drought stress conditions.

## DISCUSSION

Plant morphology is strongly impacted by environmental conditions (Lisar *et al.*, 2012). Plant health can be determined by tracking the moisture state of soil, which is consider crucial for plant development under drought stress conditions (Hazem *et al*., 2024). Reduce soil moisture alter plants morphology, physiological and molecular functions especially at seedling growth stage (Giordano *et al*., 2021). These changes impact the majority of plant metabolism functions such as reduction in photosynthetic rate for plant metabolism (Farooq *et al.*, 2009). Pereira (2004), claims that water stress acts by slowing down plant evapotranspiration rate, and the related physiological processes including respiration, photosynthesis and nutrient assimilation. Furthermore, under drought stress (50% water). Mohamed *et al*. (2021), demonstrated reduction in seedling growth as compared to normal conditions, who are in agreement with our findings.

Drought-tolerant watermelon plants have emerged as a useful model for researching mechanisms behind drought tolerance to demonstrate plants abilities in maintain their system throughout drought stress duration (Madumane *et al*., 2024), because of the effects of drought stress differ not only between species, but also within species, because of different genotypes have displayed distinct response patterns (Naresh *et al.*, 2024). Because dry matter contents are linked to numerous vital components of plant growth, which are confirmed in our study. Additionally, it has been observed that dry matter content in watermelon plant parts depend upon genotype. Consequently, the inhibition of cell divisions in shoot and root tips may be cause decrease in shoot and root growth. Thus, watermelon plants with higher dry weight may be able to grow and develop more effectively under drought stress conditions (Khandaker *et al.*, 2020), due to special function of gene expression for each genotype, which were in consist with previous reports in (Pereira *et al.*, 2020). Therefore, it is thought that reaction of plants to drought stress can be predicted quite well from the performance of seedling due to the fact that seedlings are primary source of assimilation allocated to reproduction and fruiting. Specifically, under both studied conditions, Giza-1 were performed best, while Aswan and Fagr-101 were performed well following Giza-1, otherwise Sina were performed low.

## CONCLUSIONS

The study's finding supports the idea that Giza-1 were performed best under both conditions, while Aswan and Fagr-101 were performed well under normal and drought stress conditions, respectively following Giza-1. Moreover, the most effective strategy for promoting drought tolerance during seedling growth was 50% water. Additionally, our knowledge not prior conducted as research in order to obtain strong prediction performance for drought tolerance. Hence, more research can be done to create broad models that predict multiple morphological traits, which would be useful for introgression by using biotechnology tools.

## FUTURE SCOPE

Hybrids Aswan under normal and Fagr-101 under drought were performed well following Giza-1, which could be useful as a parental material in future breeding programs.

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**Conflict of Interest.** None.

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