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THE ROLE OF SOAKING THE SEEDS WITH CALCIUM SALT SOLUTIONS BEFORE PLANTING TO REDUCE THE HARMFUL EFFECTS ON THE GROWTH CHARACTERISTICS OF WATER-STRESSED WHEAT PLANTS

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ABSTRACT : This study was applied in the Agriculture Division of Bani Saad, Agriculture Directorate of Diyala, for the agricultural season 2020-2021. Wheat, *Triticum eastivum* L. seeds of Aba 99 variety were obtained from the Plant Production in Agriculture Directorate of Diyala. The study was implemented as a global experiment according to a completely randomized block design, with four replications, using three types of calcium salt solutions (chloride, sulfate and calcium phosphate), in addition to soaking with distilled water and not soaking the seeds before planting, and four levels of water stress by adding 25% irrigation water 50%, 75% and 100% of the field capacity. Wheat seeds were sown on 18/12/2020, and the chlorophyll content of the leaves, the area of the flag leaf, the number of branches in the plant, the content of proline, the content of potassium and sodium in the leaves, and the height of the plant were studied. The results of the study showed that soaking the seeds before planting with calcium salts led to a significant increase in the studied growth characteristics and a decrease in chlorophyll content in the leaves, and irrigation at field capacity and 75% of it led to a significant increase in most growth characteristics. However, irrigation at field capacity and 75% of it caused a decrease and increase in proline with a decrease in moisture content, a decrease in the sodium content in the leaves and an increase in it whenever the moisture content decreased, and an increase in the content of potassium and chlorophyll in plant leaves at the field capacity and 75% of it, and their decrease at irrigation by 50% and 25% of field capacity.

Key words : *Triticum eastivum*, proline, chloride, sulfate and calcium phosphate.

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INTRODUCTION

Drought has become one of the main obstacles to agricultural development, especially in areas that lack water. Studying the effect of different water stresses on photosynthesis, growth and yield, and the effect of water use efficiency (WUE) and irrigation water productivity (IWP) of wheat will provide data for developing scientific strategies for methods of irrigated planting. According to the field water capacity, four levels of field water capacity were determined, *i.e.* 30-40% severe stress, 40-50% moderate stress, 50-60% light stress, and 60-80?% good stress of field water capacity, and controlling the amount of water Irrigation through an automated irrigation system (Zhao *et al*, 2020). The importance of soaking the seeds with calcium chloride and distilled water is based on the importance of calcium and water in the early stages of seedling growth. Calcium is considered to be one of the components involved in the composition of cell membranes, as it stimulates a number of enzymes related to the growth process as an enzyme (Amylase, adenylate cyclase, Phospharlase and Nitrate rrductase). In addition to its role as a second messenger in the cell, water also plays a very important role in building and activating a number of enzymes during the early stages of germination (Al-Anbari, 2007). Komalasari Oom and Ramiah Arief (2020) indicated that through a study conducted on soaking sorghum seeds for different periods of 2, 4, 6, 8, and 19 hours, it had a significant effect on growth characteristics by increasing length and dry weight of root and stem. The two-hour soaking treatment had a significant effect on the vigor or activity of the seeds, in the mean of germination, root and stem length, and root and stem dry weight. Chen and Hao (2015), Ali *et al* (2018) and Zhao *et al* (2020) indicated that drought can affect plant physiological parameters such as chlorophyll content, photosynthetic measurements, biomass and yield.

Tankari *et al* (2019), Mathobo *et al* (2017) and Torabian *et al* (2018) reported that so far, many scientists have studied how soil water content or the relative water content of leaves affects photosynthesis. As Izanloo *et al* (2008) and Carmo-Silva *et al* (2010) show, studies have indicated that dehydration causes stomata or non-stromal restriction during photosynthesis or both of them. Hura *et al* (2007) added that dehydration causes a decrease in intracellular CO_2 concentration, which leads to the determination of photosynthesis. Non-stomatal determination can be defined as the inhibition of Rubisco, an enzyme that plays a role in the first major step in carbon fixation. It is a process concerned with converting CO_2 in atmospheric air by plants into molecules with a high energy content such as glucose or short ATP, reducing the content of photosynthetic pigment or reducing the participation of enzymes of the photosynthetic system in helping light to stop photosynthesis of the crop (Friso *et al*, 2004 and Gomez-Bbellot *et al*, 2020). Farkas *et al* 2020) showed that drought reduces the photosynthetic period of wheat during flowering and in the flag leaf stage, water deficiency leads to a decrease in the metabolic rate, moreover, drought speeds up the metabolic analysis during old age. Ibrahim (2010), also concluded that the mean of number of tillers was significantly affected by the number of waterings, as the irrigated treatment of 6 waterings gave the highest mean of the number of tillers/ plant, while the irrigated treatment (3) waterings gave the lowest mean for this characteristic. Assuero and Tognett (2010) mentioned that the branching process in grasses is usually and severely affected by the low amount of water ready for the plant. Baque et al. (2006) mentioned in their study on wheat plants after exposing them to two levels of water stress (25% and 37.5% depletion of field capacity). In addition to the comparison treatment, there are significant differences in the number of tillers per plant, as the two stress treatments 25% and 37.5% gave means of 2.63 and 1.52 tillers/plant, respectively. Al-Derfasi *et al* (2002) explained that the exposure of wheat plant to water stress during the vegetative growth stage caused a decrease in the leaf area due to the reduction in the size of the cells due to the water stress and the decrease in the relative water content and the ability of cells to elongate. Dahl and Kadhem (2017) mentioned the decrease in the area of the flag leaf when the plant was exposed to high levels of drought. As for Akram (2011), Hayer *et al* (2021) he indicated that there was a significant increase in the chlorophyll content of leaves when the wheat plant was exposed to a moderate water stress of 1.22 $mg.cm^{-2}$ compared to the regular irrigation treatment, which gave a mean of 0.98 $mg.cm^{-2}$. Nikolaeva et al (2010) and Shalaby (2020) showed that under drought conditions there was a decrease in chlorophyll content of leaves and that the decrease of chlorophyll b was more as compared to chlorophyll a. Verbraggen and Hermans (2008) pointed out that proline has the largest role in drought tolerance. Moaveni (2011) added in his study on the effect of water stress on wheat for two seasons that the level of proline increases in the case of water stress. Tatar and Gevrek (2008), Kameli and Losel (1996), Johari-pireivatlou (2010) also showed that the production of wheat from dry matter increases with a decrease in the relative water content and an increase in the content of proline under drought stress. Based on what has discussed above, this study aims to know the effect of seed soaking treatments before planting with calcium salts on the growth characteristics of wheat plants, their role in reducing the damage of water stress and studying the effect of water stress on the growth parameters of wheat plants, as well as knowing the best soaking treatment for seeds before planting and at any water stress to give the best growth characteristics of wheat plant.

MATERIALS AND METHODS

The experiment was carried out in plastic pots, which were 38 cm in diameter and 45 cm high, with a value of 5 kg of soil/pot. As a global experiment according to a randomized complete block design with four replications, using three types of calcium salt solutions (chloride, sulfate and calcium phosphate). In addition to the two treatments of soaking with distilled water and not soaking the seeds before planting and four levels of water stress by adding irrigation water at the rate of 25%, 50%, 75% and 100% of the field capacity. Wheat seeds were planted on December 18, 2020, as 15 seeds were placed for each pot at a depth of 3 cm. Nitrogen and super phosphate fertilizers were added to all experimental units and according to the fertilizer recommendations approved by the Iraqi Ministry of Agriculture. Measurements of growth characteristics were taken in the elongation stage before flowering date and they are:

Total chlorophyll content of leaves ($mg.100gm^{-1}$ fresh weight):

Based on the method of Goodwin (1976).

The area of the flag paper (cm^2):

The area of the flag leaf was calculated at the stage of expulsion of the spikes based on the following equation:

Area of the flag paper = length of paper x maximum paper width × 0.95 (Thomas, 1975). Number of branches. Pot^{-1}:

The number of tillerss for each pot was calculated from the base of each of the five plants that were grown. Estimation of leaf content of proline acid ($mg.gm^{-1}$). The proline acid content was estimated according to Bates et al. (1973). Estimation of potassium and sodium content of leaves (%): Potassium and sodium were estimated in the digested leaf samples using a flame photo meter by the method of Wiessmann and Nehring (1960). plant height (cm) The height of the plant was measured from the crown area in contact with the soil surface and the top of the spike without the sap (Singh and Stoskopf, 1971). The data were statistically analyzed according to the method of analysis of variance for a factorial experiment in terms of designing randomized complete sectors (Al-Rawi, 1984), using the SPSS program, the fourteenth edition, and the significant differences between the means were compared on the L.S.D. test, at the probability level of 0.05.

RESULTS AND DISCUSSION

Chlorophyll content ($mg.100gm^{-1}$) in wheat germ leaves

The results in Table 1 indicate that there are highly significant differences between the mean treatments of soaking seeds before planting in calcium salts, as the mean of leaves content of chlorophyll decreased in those treatments. As the soaking treatment with calcium sulfate recorded the lowest mean of chlorophyll content and it reached 39.675 mg^{-1} compared to the non-soaking treatment, which gave the highest mean of chlorophyll content and reached 43.125 $mg.gm^{-1}$. The reason may be attributed to the fact that the saline solutions reduce chlorophyll a and b due to the effect on the enzymes responsible for the formation of pigments or secondary products, and this is consistent with what Al-Rubaie (2002) mentioned. The results in the same table show that there are highly significant differences between the means of the treatments, as the chlorophyll content in the leaves of the plant decreased when the moisture content decreased to less than the field capacity, especially at 50% and 25% of the field capacity, as these two treatments gave the lowest means in the chlorophyll content They reached 40,200 and 38.760 $mg.100\ g^{-1}$ compared to irrigation at field capacity and irrigation at 75% of it, and the reason may be attributed to the destruction of chlorophyll and the slow speed of its construction, as well as the drought conditions that reduced the content of chlorophyll and that chlorophyll b is more compared to chlorophyll a, and this result is consistent with what was reported by Shalaby *et al* (2020), Nikolaeva *et al* (2010) and Al-Obaidi (2015). As for the effect of the interaction of the study factors, the results in Table 1 indicated that there were significant differences between the means of the treatments of the study factors, as the mean of chlorophyll content decreased in the treatments of soaking the seeds before planting with a decrease in the amount of irrigation, as it gave the lowest mean of chlorophyll content when soaking with calcium chloride and irrigation when irrigating with 25% of the field capacity and amounted to 36,300 mg^{-1}. The same result was achieved when the seeds were soaked with calcium sulfate and irrigated at 50% of the field capacity.

Flag Leaf Area (cm^2)

The results shown in Table 2 show that there are highly significant differences between the mean treatments of soaking wheat seeds before planting, as treatments of soaking seeds in brine solutions of calcium chloride and calcium phosphate recorded the highest mean in the area of the flag leaf and reached 33.666 cm^2 and 33.188 cm^2 respectively, followed by soaking with sulfate Compared to the treatments of non-soaking and soaking with distilled water, the reason may be attributed to the fact that soaking with these salts will increase the root growth, which is reflected on the growth of the vegetative total in full, whether the height of the plant, the number of leaves or the leaf area. The results in Table 2 show that irrigation with different percentages of the field capacity led to a significant decrease in the mean of this trait, as the results showed that there were highly significant differences between the means of the transactions, as the means of the area of the flag leaf decreased when the irrigation rates were lower than the field capacity, varyingly depending on the percentage of the decrease, as the irrigation treatment at the field capacity and 75% of it recorded the highest means in the area of the flag leaf, reaching 39.153 cm^2 and 33.153 cm^2, respectively, compared to 50% and 25% of the field capacity, as the percentage of decrease was 29.104% at 50% of the field capacity and 35.172% at 25% of the field capacity. The reason may be due to the fact that the leaves with a large area are more exposed to sunlight and more in contact with the surrounding air, which leads to the loss of an important amount of water per unit area of the leaf compared to the leaves of lesser area. Adaptation to reduce water requirements and paper wrapping, which can be a sign of loss of fullness, as well as an escape from drought. This result was in agreement with what was mentioned by Amokrane *et al* (2002) and Belkharchonche *et al* (2009). The results also show that there are highly significant differences when the two study factors overlap (soaking treatments and irrigation treatments with different percentages of field capacity), as seed soaking treatments with chloride were recorded.

Table 1 : Effect of seed soaking before planting and irrigation treatments at different percentages of field capacity on the mean of chlorophyll content (mg.100gm^{-1}) in wheat leaves.

Irrigation at	Socking with					Mean
	No soaking	Water	$CaCl_2$	$CaSo_4$	$Ca_3(PO4)_2$	
F.C.	44.800	41.600	40.600	45.800	42.200	43.000
%75	45.500	43.300	42.100	43.400	40.900	43.040
%50	42.500	40.900	39.700	36.300	41.600	40.200
%25	39.700	37.800	36.300	41.500	38.500	38.760
Mean	43.125	40.900	39.675	41.750	40.800	41.250
L.S.D.	Soaking= 0.769	Irrigation = 0.688	Interaction = 1.538			

Table 2 : The effect of soaking seeds before planting and irrigation treatments at different percentages of field capacity on the mean of the flag leaf area (cm^2) of wheat plant.

Irrigation at	Socking with					Mean
	No soaking	water	$CaSO_4$	$Ca_3(PO4)_2$	$Ca_3(PO4)_2$	
F.C.	33.930	31.485	46.892	38.750	46.017	39.153
%75	32.746	33.262	32.537	33.682	33.437	33.153
%50	27.550	28.430	27.012	27.232	28.567	27.758
%25	26.112	24.975	28.222	22.867	24.732	25.382
Mean	30.185	29.538	33.666	30.633	33.188	
L.S.D.			Soaking= 1.495	Irrigation = 1.337	Interaction = 2.990	

Table 3 : The effect of soaking seeds before planting and irrigation treatments at different percentages of field capacity on the mean number of tillers of wheat plant.

Irrigation at	Socking with					Mean
	No soaking	water	$CaCl_2$	$CaSo_4$	$Ca_3(PO4)_2$	
F.C.	19.75	20.25	22.50	20.50	20.00	20.60
%75	19.75	20.75	20.50	20.75	20.50	20.85
%50	18.25	17.75	20.00	19.25	19.75	19.00
%25	16.50	18.75	17.50	16.50	20.00	17.85
Mean	18.56	19.38	20.13	19.25	20.56	
L.S.D.	Soaking= 0.721	Irrigation = 0.645	Interaction = 1.445			

Calcium, calcium phosphate and irrigation at field capacity were the highest means in the area of the flag leaf compared to other treatments when the plant was exposed to water stress or moisture depletion and they reached 46,892 cm^2 and 46.017 cm^2, respectively.

Number of Tillers per plant^{-1}

The results in Table 3 show that there is a significant increase in the number of branches of the plant when soaking the seeds before planting with calcium phosphate salt, as the highest mean reached 20.56 branches, compared to non-soaking, and this result is consistent with what was mentioned by Al-Salihi (2008) and Al-Obaidi (2015), as for the effect of Irrigation with different percentages of field capacity. The results show that the number of branches decreases significantly with a decrease in field capacity, as the highest number of plant branches reached at field capacity and 75% of them were 20.60 and 20.85 branches, respectively. Perhaps the reason is that the branching process in the grasses is strongly affected by the low amount of ready water, and the effect of water stress in reducing the number of branches depends on the time and intensity of the stress. This result is consistent with what Assuero and Tognetti (2010) mentioned. The results also showed that there were significant differences in the mean number of branches in the treatments of soaking the seeds before planting, whether with distilled water or calcium salt solutions when the soil moisture content increased in the field capacity or 75% of it, as the highest mean was recorded when soaking the seeds with calcium chloride salt and irrigation at capacity field, then it begins to decrease when moisture is depleted for all other treatments.

Proline content of leaves (mg.gm^{-1})

The results in Table 4 indicate that there are highly significant differences between the means of the treatments of soaking seeds in calcium salt solutions, as those treatments gave the highest means (phosphate, chloride and calcium sulfate) 3.9719, 3.8450 and 3.8775 mg.gm^{-1}, respectively, compared to the treatment of no soaking. Or soaking with water, and the reason may be due to the fact that when the plant stimulates the seeds

Table 4 : The effect of soaking seeds before planting and irrigation treatments at different percentages of field capacity on the mean of proline content (mg.g^{-1}) in the leaves of the wheat plant.

Irrigation at	Socking with					Mean
	No soaking	water	$CaCl_2$	$CaSo_4$	$Ca_3(PO4)_2$	
F.C.	1.720	2.080	3.700	3.680	3.650	2.966
%75	2.300	2.620	3.460	3.210	3.620	3.042
%50	2.710	3.160	4.290	3.870	4.117	3.629
%25	3.367	3.540	3.930	4.390	4.500	3.945
Mean	2.524	2.850	3.845	3.787	3.971	
L.S.D.	Soaking= 0.102 Irrigation = 0.091 Interaction = 0.205					

Table 5 : The effect of soaking seeds before planting and irrigation treatments at different percentages of field capacity on the mean of sodium in the leaves of the wheat plant.

Irrigation at	Socking Treatments					Mean
	No soaking	water	$CaCl_2$	$CaSo_4$	$Ca_3(PO4)_2$	
F.C.	0.189	0.168	0.159	0.150	0.158	0.164
%75	0.175	0.179	0.180	0.163	0.173	0.174
%50	0.200	0.172	0.207	0.182	0.196	0.191
%25	0.214	0.188	0.192	0.205	0.183	0.196
Mean	0.194	0.176	0.184	0.175	0.177	
L.S.D.	Soaking= 0.0004 Irrigation = 0.0004 Interaction = 0.0009					

with calcium solutions, it begins to adapt to reduce sodium damage, which may be in irrigation water or soil. Proline acid is biologically constructed from glutamine acid, and this result is consistent with what Hanson and Hitz (1982) mentioned. As for the effect of irrigation treatments at different percentages of field capacity, the results shown in Table 4 indicated that there were highly significant differences between the means of treatments for proline content, as the proline content increased significantly as the moisture depletion of water by the plant increased, and the lack of need was not compensated by irrigation. Irrigation treatment at 25% of field capacity recorded the highest mean of proline content (mg.g^{-1}) and it reached 3.9455 mg.gm^{-1}, compared to irrigation at field capacity. The reason may be attributed to the fact that the plant has defensive means against stress, including water stress, by increasing secondary metabolites during the photosynthesis process, since these substances constitute the second line of defense for the plant, as well as being a source of pigments, energy and compensation for the deficiency in nutrients. cited by Verbraggen and Hermans (2008). Concerning the effect of the interaction, the results of Table 4 showed that there were significant differences between the means of the treatments, as the proline content increased with an increase in moisture depletion at 50% and 25% of the field capacity and reached 4.117 and 4.500 mg.gm^{-1}, respectively.

Sodium content of leaves (%)

The results of Table 5 show the significant differences between the means of soaking wheat seeds treatments before planting, as they showed a decrease in the sodium content in plant leaves compared to the non-soaking treatment, which amounted to 0.1769, 0.1848, 0.1751 and 0.1776% for the treatments of soaking with water, chloride, sulfate and calcium phosphate respectively, and perhaps The reason is attributed to the fact that calcium salts reduce sodium absorption, and this agrees with what was stated by Al-Salihi (2008). Regarding the effect of irrigation treatments at different percentages of field capacity, the results of Table 5 showed that there were significant differences between the averages of treatments, as the sodium content of the leaves increases as a result of the decrease in moisture content. The leaves of the plant amounted to 0.1917 and 0.1968% respectively, and this is due to the accumulation of salts as a result of moisture depletion, especially at 50% of the field capacity, and this will affect the physiological processes of the plant, the most important of which is the lack of CO_2 absorption, thus affecting the photosynthesis process. As for the effect of the interaction of the study factors, the results of Table 5 indicated significant differences between the means of the treatments, as the sodium content increased with a decrease in the moisture content, and the non-soaking treatment recorded the highest mean of sodium when irrigated by 25% of the field capacity and amounted to 0.2142% compared to other treatments.

Potassium content of leaves (%) of wheat

The results of Table 6 indicate the significant differences between the treatments of soaking the wheat seeds before planting in calcium salts, as the treatment of soaking the seeds in calcium sulfate recorded the highest mean of potassium content of leaves, which amounted to 1.38% compared to other soaking treatments,

Table 6 : Effect of soaking seeds before planting and irrigation treatments at different percentages of field capacity on the mean of potassium in the leaves of the wheat plant.

Irrigation at	Socking with					Mean
	No soaking	water	$CaCl_2$	$CaSo_4$	$Ca_3(PO4)_2$	
F.C.	1.350	1.390	1.380	1.4200	1.4000	1.3880
%75	1.360	1.310	1.400	1.4500	1.3200	1.3680
%50	1.290	1.350	1.3300	1.3600	1.3100	1.3280
%25	1.250	1.260	1.2700	1.2900	1.2600	1.2660
Mean	1.312	1.327	1.3450	1.3800	1.3225	
L.S.D.	Soaking= 0.064	Irrigation = 0.064	Interaction =N.S.			

Table 7 : Effect of soaking seeds before planting and irrigation treatments at different percentages of field capacity on mean of wheat plant height.

Irrigation at	Soaking treatments					Mean
	No soaking	water	$CaCl_2$	$CaSo_4$	$Ca_3(PO4)_2$	
F.C.	60.490	55.590	71.475	55.880	63.582	61.399
%75	52.980	56.082	57.020	48.165	48.727	52.595
%50	46.977	44.425	52.842	47.602	54.620	49.293
%25	44.965	51.327	56.387	29.295	50.760	46.547
Mean	51.353	51.856	59.431	45.235	54.417	
L.S.D.	Soaking=3.929	Irrigation = 3.514	Interaction = 7.859			

and this is attributed to the role of calcium in reducing sodium absorption and increasing potassium absorption. With respect to the effect of irrigation treatments at different means of the field capacity, the results in Table 6 indicated the significant differences between the means of the treatments, as the potassium content of the leaves decreased as a result of the decrease in moisture content, and the irrigation treatment at 25% of the field capacity recorded the lowest mean for this trait and amounted to 1.266%. The reason may be attributed to the fact that potassium is one of the adsorbing elements on the clay colloids, and this adsorption increases when water stresses and the lack of absorption by the plant and consequently its decrease in the leaf. Also, that during drought stress, the stomata cannot perform their function accurately in plants with weak potassium content, as a result Significant water loss and this result is consistent with what was reported by Wang *et al* (2013).

Plant height (cm)

The results of the analysis of variance (Appendix 1) and Table 7 show that irrigation at different field capacities led to a highly significant decrease in the mean of plant height, as it decreased by 6.045% 19.716% and 24.184% from the mean of plant height at field capacity sequentially, compared to irrigation at capacity This result is consistent with what Al-Budairi (2013) mentioned, that the height of wheat plants decreased significantly when exposed to water stress and the reason can be attributed to the fact that water stress leads to a decrease in the relative water content of the plant, which limits the division and expansion of plant cells, as the availability of soil water reduces photosynthesis processes (Idris, 2009). Also, water stress led to a decrease in the chlorophyll content of the leaves (Table 1), thus reducing the photosynthesis process, and this was reflected in cell division and elongation, which affected the height of the stem. Concerning the effect of soaking the seeds in salt solutions, the results in Table 7 showed that there were highly significant differences between the means of plant height. It increased when the seeds were soaked with chloride, and the mean of plant height was 59.431 cm, with an increase of 5.730% when compared with the comparison treatment (non-soaking). As for the effect of the interaction of factors, the results showed significant differences between the means of plants height, as the height of the plant increased when the seeds were soaked before planting with chloride salt and irrigation at field capacity and the mean of plant height was 71,475 cm (Table 7) and perhaps the reason is due to the increase in moisture content may increase cell division and reduce the effect of the mean of salts that the seed may contain as a result of soaking.

CONCLUSION

Through the results, we can conclude that the best treatments are soaking the seeds before planting in calcium salts because the increases in growth characteristics occurred in the soaking treatments, and that the best treatments are those irrigated at field capacity or 75% of them compared to other irrigation treatments. Furthermore, the best results were obtained when the complete irrigation reaction (field capacity or 75% of the field capacity)in growth characteristics.

Recommendations

Based on the conclusions, it can be recommended to adopt soaking wheat seeds before planting using advanced scientific methods because this method is used in limited quantities and in limited areas, and full irrigation at the field capacity or 75% of it, especially in the early stages of the plant life cycle. In addition, conducting extensive studies on the duration of soaking, as well as the number of irrigations and according to the stages of plant growth.

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