Response of Some Chemical Content of Pepper *(Capsicum annuum* L.*)* to Foliar Application of Boron and Zinc under Plastic House Conditions

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Abstract

This experiment was conducted at Technical Institute Khabat, Erbil Polytechnic University in the plastic house during spring season 2015, using factorial randomized complete block design (RCBD) with three replicates, to study the effect of boron and zinc foliar application at concentrations of (0, 150 and 250) ppm on the chemical characteristic of the leaves and fruits of Flavio F1 hybrid cultivar of sweet pepper plants. The results showed that the foliar application of boron significantly increases the percentage of potassium, calcium, sodium, iron, manganese, copper, boron and zinc content in the leaves and fruits. Foliar application of zinc significantly decreases the percentage of calcium and iron content in leaves and fruits and significantly increases the sodium, manganese, copper, boron and zinc in the leaves and fruits. Boron foliar application has higher effects as compared with foliar application of zinc.
Keywords: Pepper, *(Capsicum annuum* L.*)*, foliar application, boron and zinc, plastic house.

أستجابة محتوى الفلفل (*Capsicum annuum* L.) من العناصر الغذائية للرش الورقي بالبورون والزنك المزروعة تحت ظروف البيت البلاستيكي

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الخلاصة

تمت أجراء هذه التجربة في المعهد التقني- خبات، جامعة أربيل التقنية في البيت البلاستيكي للموسم الربيعي ٢٠١٥، بأستخدام تجربة عاملية بتصميم القطاعات العشوائية الكاملة بثلاث مكررات، لدراسة تأثير الرش الورقي بالبورون والزنك بتراكيز (٠، ١٥٠، ٢٥٠) جزء من المليون على الصفات الكيميائية للاوراق والثمار للصنف الهجين فلافو لنبات الفلفل الحلو. بينت النتائج بأن الرش الورقي بالبورون أظهرت زيادة معنوية في النسبة المئوية للبوتاسيوم، الكالسيوم، الصوديوم ومحتوى الحديد، المنغنيز، النحاس،البورون والزنك في الاوراق والثمار. أما الرش الورقي بالزنك أظهرت نقص معنوي في النسبة المئوية للكالسيوم ومحتوى الحديد في الاوراق والثمار مع أعطاء زيادة معنوية في النسبة المئوية للصوديوم ومحتوى المنغنيز ، النحاس،البورون والزنك في الاوراق والثمار. وقد أظهرت النتائج بأن الرش الورقي بالبورون كان أكثر تأثيراً مقارنة بالرش الورقي بالزنك.
الكلمات المفتاحية : الفلفل، البورون، الزنك، البيت البلاستيكي.

Introduction

Sweet pepper (*Capsicum annuum* L.) is a summer vegetable crop which belongs to the solanaceae family, pepper is a warm season plant with distinct temperature requirements for producing a marketable yield. The minimum soil temperature for seed germination is 15° C with maximum of 35° C and an optimum range of 18° C to 29° C (Hassan, 2001). Fruits set for many cultivars fail when temperature drops below 13° C to 18° C, and at the temperature above 37° C affects fruits development (Salunkhe and Kadam, 1998).

Sweet pepper fruits are regarded as a rich source of compounds such as vitamin C, polyphenols, carotenoids and sugars (Topuz and Ozdemir 2007). However, some elements contents especially, calcium, phosphorus and iron are present in sweet pepper fruit (Salunkhe and Kadam, 1998).

Micronutrients are those elements which are essential for plant growth and development, and many physiological functions including structural enzymatic, regulatory and ionic. Foliar spraying of micronutrient is very helpful when the roots cannot provide necessary nutrients and is an effective method of supplying nutrients during the period of intensive plant growth when it can improve plants mineral status and increase crop yield (Kolota and Osinska, 2001).

Boron is one of the important micronutrients to plant growth and have multiple roles like metabolism of carbohydrates, phenol and auxins, transport of sugars, tissue development, differentiation and formation of cell walls, water relations, reproduction and disease resistance (Tariq and Mott, 2007 a). Also boron has major effects upon root elongation, nucleic acid metabolism, flower formation, seed production and membrane function (Barker and Pilbeam, 2007).

Zinc is also an essential micronutrient involved in a wide variety of physiological processes such as metabolism of carbohydrates, proteins, phosphates and auxins, RNA and ribosome formations and activity as component of variety of enzymes such as dehydrogenases, proteinases and peptidases (Tsonev and Lidon, 2012).

Tariq and Mott (2006 b) concluded that the concentration of boron, zinc and copper was increased and the concentration of iron and manganese was decreased when supplied boron to the radish plant. Also the same researchers in (2007 c) reported that the concentration of calcium and boron in radish plant increased with increasing the levels of boron foliar application.

Hossain (2008) found that there are significant effects of different levels of boron and zinc on the potassium, calcium, magnesium, boron and zinc content in the fruits and leaves of tomato plants.

Saad (2015) showed that foliar application by boron and zinc significantly increases the potato boron, zinc and potassium seed contents of faba bean.

The aim of this experiment was to estimate the content of some mineral nutrients such as (potassium, calcium, magnesium, sodium, iron, manganese, copper, boron and zinc) in the fruits and leaves of pepper plant (Flavio F1 cultivar) affected by foliar application of boron and zinc grown under the plastic house conditions.

Materials and Methods

The experiment was conducted under the plastic house in the farm of Technical Institute Khabat, Erbil Polytechnic University, from April 20th, 2015 to August 10th, 2015 to study the effect of foliar spray solution of different levels of boron and zinc (0, 150, 250) ppm on mineral content of sweet pepper fruits and leaves grown in the plastic house (dimension of fifty meter in length, nine meter in width and three in height). Flavio F1 cultivar was chosen for this study, plant belong to hybrid cultivars produced by Nunhems Company having good characteristics and almost no study is carried out on this cultivar in the region.

The experiment was designed as factorial randomized complete block design (RCBD) comprising of six treatments and three replicates. There were 18 plots, and each plot contained 10 plants. The distance between the plants was (40cm).

Seeds of the pepper plant were sown in the pot from April 20th, 2015 and seedling were transplanted to the plastic house when the seedling reach the appropriate size during May 30, 2015. All the cultivation practices for pepper plant were carried out according to growing area. The plants were supplied with NPK with soluble fertilizer by injecting in the irrigation water each week (Hassan, 2001), and micro plant nutrients (boron and zinc) were sprayed on the leaves in three stages and all foliar spraying was carried out early in the morning till run-off and a surfactant agent Tween was added at concentration 0.1% to the solutions. The most serious pests and diseases were observed on the plants in the plastic house. For the pests and diseases control pesticides and fungicide were used (table 1) and were controlled with ventilation in the plastic house.

The data collected was analyzed statistically using SPSS (Statistical Package for Social Sciences) program, version (22.0) in 2015. Comparisons between means were made by using Tukey HSD test at 5% probability and the comparisons between effects of boron and zinc were made by using t-test.

The harvest were carried out from July 30th, 2015 and the data were recorded for chemical characteristics from 8 random plants to each experiment unit for determined (potassium, calcium, magnesium, sodium, iron, manganese, copper, boron and zinc) in the fruits and leaves. The fruits and the leaves were dried at 70 C° for 72 hours, then ground by electrical grinder for each experimental unit. A one gram of ground sample was digested by adding 10 ml of concentrated H_2SO_4 and 10 ml of H_2O_2 with heating for digestion as described by Ryan *et al.*, (2001). The concentration of (potassium, calcium and sodium) % were determinate from digested samples by flame photometer and the concentration of (magnesium %) and (iron, manganese, copper and zinc) ppm were determined from digested samples by atomic absorption (Gupta, 2006). The samples were prepared for boron determination as described by Paasikallio (1978), in which a 10g of ground plant sample ashes at 450c° for 18 hours in the quartz crucible and then dissolved by (1:1) HCL. The final volume of the sample solution was completed to 50ml with distilled water. Boron content was determined by Carmine method as mentioned by Welcher (1983).To 25ml volumetric flask 2ml of sample solution, (2-3) drops of HCL, 10ml of concentrated H_2SO_4, and 10ml of carmine solution (25mg dissolved in 100ml H_2SO_4) were added. The solution was left for 45 minutes, then the absorbance for the sample and standers were measured by 585nm against reagent blank by spectrophotometer.

Table 1. Fungicide and pesticide were used in the experiment

Name	Type	Chemical composition	Average use
Avanut	Pesticide	Indoxacarb	15mL/20L
ORIZON$_{-st}$	Pesticide	Acetamiprid + Abamectin	15-20mL/20L
Topsin-M	Fungicide	Thiophanate methyl	75gm/100L
Rival	Fungicide	Propamocarb hydrochloride	100mL/100L
Equation pro	Fungicide	Cymoxanil + Famoxadone	8gm/20L

Results and Discussion

1 - Effect of different concentrations of boron foliar application on (K, Ca, Mg, Na, Fe, Mn, Cu, B and Zn) of the leaves and fruits of sweet pepper

Potassium (%): Table (2) and (3) show the effect of foliar application of boron on different levels on the percentage of potassium in the leaves and fruits. Significant differences were observed of the percentage of potassium in the leaves and fruits by boron treatment and the highest value (5.233 ppm) was recorded at 250ppm. These results agreed with those obtained by Shafeek *et al.* (2014) concerning hot pepper plant and El-Dissoky and Abdel-Kadar (2013) concerning potato plant.

Boron and potassium have over lapping roles to play in plant physiology and hence, are synergistic. Tariq and Mott (2007 d) reported that the effects of boron and membrane permeability could lead to association between boron and potassium and the stimulation of potassium accumulation by the ATPase protein pump which may account for positive correlations between potassium and boron.

Calcium (%): As seen in table (2) and (3) boron foliar application significantly increased the percentage of calcium in the leaves when compared with control and significant differences were found between all treatments of the percentage of calcium in the fruits. The maximum value (3.600%) was recoded at 150ppm in the leaves and the minimum value (0.867%) was recorded from control in the fruits. These results are similar to the findings of Samet *et al.* (2015) concerning pepper plant.

Tariq and Mott (2007 c) found that boron deficiency induces abnormal change in the metabolism of the cell wall, however, has specific effect on calcium translocation and incorporation in to an insoluble from i.e. as cell wall components.

Table 2. Effect of boron concentrations on some nutrient contents of the leaves

Boron concentration (ppm)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Zn (ppm)
0	3.347	1.467	1.030	0.190	307.400	56.767	13.033	24.500	72.733
150	5.167	3.600	1.075	0.250	317.833	65.333	19.167	58.700	79.933
250	5.233	3.467	1.073	0.293	319.633	69.967	20.700	68.567	81.967
Tukey test	0.198	0.161	0.025	0.018	0.503	0.588	0.452	0.832	0.553

Table 3. Effect of boron concentrations on some nutrient contents of the fruits

Boron concentration (ppm)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Zn (ppm)
0	2.267	0.867	0.630	0.103	311.100	39.633	7.267	19.700	30.700
150	3.733	1.933	0.823	0.130	319.967	48.700	10.233	34.567	35.367
250	4.033	2.267	0.697	0.160	321.500	50.867	11.267	40.633	36.167
Tukey test	0.096	0.060	0.026	0.001	0.598	0.778	0.360	0.459	0.599

Magnesium (ppm): No significant difference of the percentage of magnesium in the leaves and fruits was observed in the tables (2 and 3). These results agreed with those obtained by Samet *et al.* (2015) concerning pepper plant.

Sodium (%): According to the results presented in table (2) and (3), significant differences were observed in the percentage of sodium in the leaves by boron foliar application. While, in the fruits, significant differences were found between 250ppm and control. These results partially agreed with Lee (2006) concerning hot pepper plant and Samet *et al.* (2015) concerning pepper plant.

Iron (ppm): Table (2) and (3) indicated the effect of foliar spray of boron on leaves and fruits iron content. It is found that iron content in the leaves and fruits significantly increased by boron treatment as compared with control. These results are similar to the results of Najm (2005) who reported that iron concentration in the leaves and fruits of tomato plant is increased by increasing boron concentration.

Manganese (ppm): Table (2) and (3) show that there are significant differences in the leaves and fruits manganese content between treatments. The highest value was recorded (69.967ppm) at 250ppm in the leaves. These results are partially agreed with those obtained by Dursun *et al.* (2010) concerning tomato, pepper and cucumber plants.

Copper (ppm): Table (2) and (3) indicated that copper contents in the leaves and fruits significantly increases by boron foliar treatment. These results are in agreement with Tariq and Mott (2006 b) concerning radish plant and Dursun *et al.* (2010) concerning tomato, pepper and cucumber plants.

Barker and Pilbeam (2007) reported that both boron deficiency and toxicity are consistently associated with an unbalanced ratio between boron and potassium, calcium and magnesium. The studies indicated that boron functions are different from other metabolism micronutrients but, there is some that boron may be involved in the enzymatic activity of plant. Aref (2011) concluded that the presence of a high amount of boron in the soil assisted to increasing of leaves iron, manganese and copper contents.

Boron (ppm): Table (2) and (3) observed that boron treatment led to significant increase of the boron contents in the leaves and fruits when compared with control. The maximum value (68.567ppm) was recoded at 250ppm in the leaves and the lowest value (19.700ppm) was recorded from control in the fruits. Similar result was reported by Tariq and Mott (2006 b) concerning radish plant, Hossain (2008) concerning tomato plant and Samet *et al*. (2015) concerning pepper plant.

Zinc (ppm): As shown in in table (2) and (3) there are significant differences in the leaves and fruits zinc contents between treatments and control. These results are agreed with those obtained by Tariq and Mott (2006 b) concerning radish plant and Hossain (2008) concerning tomato plant.

Tariq and Mott (2007 d) showed that in the absence of boron possibly iron became fixed in the different parts of some plants as relatively insoluble and non-movable, also reported that accumulation of phenolic compounds also to be a factor in copper deficiency and boron deficiency rendered zinc inactive in plant.

Foliar application of boron represents the most quick and efficient treatment in many cases which lead to vigorous vegetable growth and plenty of chemical constituents (El-Sherbeny *et. al*., 2007). Some studies suggest that boron effects are related to all the cation and anion values in the plant.

2 - Effect of different concentrations of zinc foliar application on (K, Ca, Mg, Na, Fe, Mn, Cu, B and Zn) of the leaves and fruits of sweet pepper

Potassium (%): No significant influence was observed in the table (4 and 5) by zinc foliar spray on the percentage of potassium in both leaves and fruits. These results are similar to the results of Shaheen *et al.* (2012) concerning spinach plant and Kazemi (2013) concerning cucumber plant.

Calcium (%): According to the results presented in the table (4) and (5) zinc foliar application significantly decreased the percentage of calcium in the leaves and fruits when compared with control. The maximum value (1.500%) was recorded for control in the leaves and the minimum value (0.467%) was recorded at 250ppm in the fruits. These results are similar to the findings of Hossain (2008) concerning tomato plant.

Magnesium (%): Table (4) and (5) show that the percentage of magnesium in both leaves and fruits are not influenced by foliar spray of zinc. These results are agreed with Hossain (2008) concerning tomato plant.

Zinc have indirect effect on potassium, the tendency of plants to maintain a constant amount of total cations on a chemically equivalent basis, however, leads to some rather complex relationships to ascribe the effect of a particular manifestation on the concentration of one particular element becomes difficult (Malvi, 2011). Macronutrients such as calcium and magnesium inhibit the absorption of zinc by plant from solution.

Table 4. Effect of zinc concentrations on some nutrient contents of the leaves

Zinc concentration (ppm)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Zn (ppm)
0	3.300	1.500	1.067	0.193	307.367	57.967	13.200	25.167	72.700
150	3.767	0.967	1.197	0.227	200.933	67.967	21.600	31.233	100.233
250	3.800	0.867	1.137	0.277	197.300	72.567	25.167	31.167	115.400
Tukey test	0.338	0.036	0.031	0.001	0.971	0.648	0.689	0.582	1.017

Table 5. Effect of zinc concentrations on some nutrient contents of the fruits

Zinc concentration (ppm)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Zn (ppm)
0	2.300	0.800	0.647	0.107	312.133	39.767	7.467	19.267	31.067
150	2.500	0.567	0.813	0.247	208.300	51.167	11.067	21.267	44.500
250	2.567	0.467	0.797	0.280	201.033	52.433	12.667	23.067	50.600
Tukey test	0.181	0.037	0.036	0.001	0.857	0.214	0.470	0.646	1.144

Sodium (%): There are significant effects on the percentage of sodium in the leaves and fruits in the table (4 and 5). These results are partially agreed with Kowalenko and Ihnat (2010) concerning cauliflower plant.

Iron (ppm): As seen in the table (4) and (5) zinc foliar application decreases the leaves and fruits iron contents when compared with control and the highest value was found form control. These results are similar to the results of Dube *et al.* (2003) concerning tomato plant.

Manganese (ppm): Table (4) and (5) show that zinc foliar spray significantly increases the leaves and fruits manganese contents .The highest value (72.567ppm) was found at 250 ppm in the leaves and the lowest value (39.767 ppm) was recorded from control in the fruits. These results are in agreement with Mousavi *et al.* (2007) concerning potato plant.

Copper (ppm): Table (4) and (5) clarify that copper content in the leaves and fruits significantly increases by zinc treatments as compared with control. These results similar to the results of Kowalenko and Ihnat (2010) concerning cauliflower plant.

Boron (ppm): Significant difference in the leaves boron content in the table (4) was observed. In the table (5) no significant effect of the fruits boron content was found. These result partially was agreed with Hossain (2008) concerning tomato plant.

The interaction between zinc and iron is also complex. Increasing the application of zinc decreases iron concentration in the shoot, and also there was an antagonism between the iron and zinc (Haffez et. al., 2013). The same researcher reported that zinc and copper may interact in several ways zinc depresses copper absorption, copper competitively inhibits zinc absorption, and copper nutrition affects the redistribution of zinc with in plants. Tariq and Mott (2007 d) reported that zinc up take was depressed in boron deficient in bean plant and the distribution of zinc in different organs corresponded to the ATPase activity localized in cell walls of roots and stem.

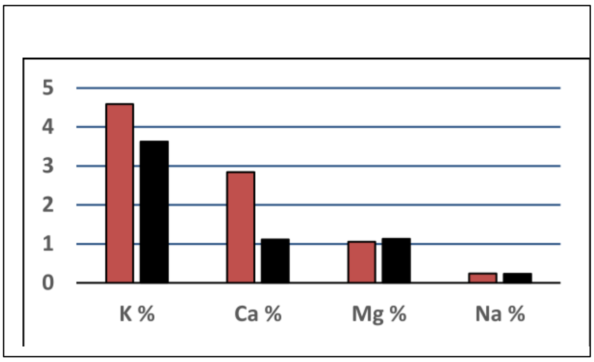
Zinc (ppm): According to the results presents in the table (4) and (5) it is found that leaves and fruits zinc contents significantly increase with increasing zinc concentration. The highest zinc content (115.400ppm) was recorded at 250ppm in the leaves and the lowest zinc content (31.067 ppm) was recorded from control in the fruits. These results are in agreement with findings of most researchers such as Mousavi *et al.* (2007) concerning potato plant and Hossain (2008) concerning tomato plant.

Zinc deficiencies have effect on the plant by stunting its growth. Interactions occur between the zinc and the macronutrients and micronutrients by affecting its availability from soils and its status in the plant throughout the growth processes, absorption, distribution or utilization (Hafeez *et. al.*, 2013).

This study shows that the foliar application of boron and zinc may affect the other nutrients ratio in plants, indicated that boron and zinc takes part in the mechanisms at the nutrients absorption and transport of other nutrient elements.

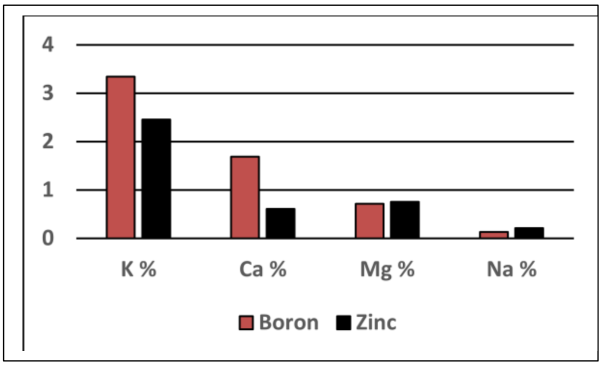
3 – Comparison between effects of boron and zinc foliar application on the leaves and fruits of sweet pepper

The statistical analysis indicated that chemical characteristics significantly are affected by foliar application by boron and zinc. Figure (1) and (2) show that significant differences between boron and zinc foliar application for the percentage of potassium and calcium in both leaves and fruits, percentage of magnesium in the leaves and percentage of sodium in the fruits. While, no significant effects between boron and zinc foliar application were observed for the percentage of sodium in the leaves and percentage of magnesium in the fruits.



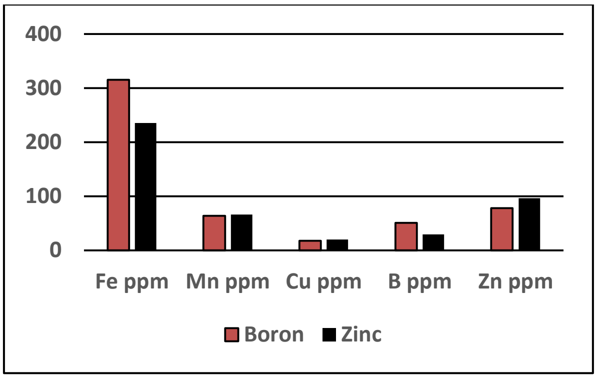
Calculate-t				Table-t
K%	Ca%	Mg%	Na%	
2.632	4.696	2.356	0.580	2.01

Figure (1): Effect of boron and zinc concentrations on some nutrient contents of the leaves.



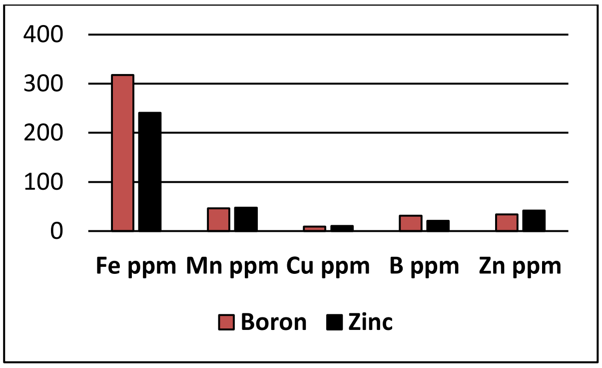
Calculate-t				Table-t
K%	Ca%	Mg%	Na%	
3.158	4.904	0.792	2.829	2.01

Figure (2): Effect of boron and zinc concentrations on some nutrient contents of the fruits.



Calculate-t (ppm)					Table-t
Fe	Mn	Cu	B	Zn	
4.391	0.711	1.084	3.159	2.784	2.01

Figure (3): Effect of boron and zinc concentrations on some nutrient contents of the leaves.



Calculate-t (ppm)					Table-t
Fe	Mn	Cu	B	Zn	
4.274	0.518	0.791	3.274	2.608	2.01

Figure (4): Effect of boron and zinc concentrations on some nutrient contents of the fruits.

Figure (3) and (4) show that iron and boron contents in both leaves and fruits significantly increase by foliar application of boron when compared with foliar application by zinc and while, zinc content in the leaves and fruits significantly increases by foliar application of zinc as compared with boron foliar feeding. In the same figure no significant effects between boron and zinc foliar spray was observed for manganese and copper contents in both leaves and fruits.

Conclusions and Recommendations

From the results of the present study, it is evidence that boron and zinc treatments may be responsible for resulting changes of nutrients uptake due to direct or indirect interaction of boron or zinc with other plant nutrients. However, the interaction of boron or zinc with the plant nutrients are highly complex and effects can be antagonistic or synergistic depending on plant species and varieties, growth medium and environmental conditions. It’s concluded that the boron foliar application significantly increases the some of nutrients content in the leaves and fruits of pepper plant (Flavio F1 cultivar) as compared with zinc foliar application.

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