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Mineral content response in onion to antioxidant application under salt stress conditions

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Abstract : Onion *(Allium cepa L*)considered one from the main vegetable crops and ranked third in Egypt for its important in diets and for exportation. In the greenhouse of National Research Centre a pot experiment was conducted to study the effect of nicotinic acid and tryptophan application under different salt stress. Plants subjected to two levels of salinity by irrigated plants with diluted seawater more than fresh water as a control. Under different salinity treatments plants divided to three groups which treated by nicotinic acid, tryptophan (in the rate of 200 ppm) and distilled water as a control. N and Ca concentration decreased parallel to the increased of salinity while K concentration decreased on by the high salinity level but P concentration increased with the subjection of onion plants to the first level of salinity and tended to decrease with the high level of salinity to be less than the control. A negative relationship was detected between salinity level and N, P, K and Ca concentration and the opposite was true for Na concentration. The concentration of Mg decreased by the first level of salts and tended to increase with the second level of salts but still less than that in control plants. The highest concentration of N and Mg was obtained by spraying nicotinic acid while P and Ca was by spraying tryptophan but for Na and K it was in control plants. The highest content of macronutrients was shown by application of nicotinic acid except for Ca it was by tryptophan application. The application of amino acids increased Ca concentration and decreased the Na concentration under different salt stress level used. Application of these two compounds improved the content of macronutrients under different salts concentration in water of irrigation. These data concluded that spraying plants with nicotinic acid improved mineral status under different salinity levels and improved the salt tolerant of treated plants.

Keywords: Onion (*Allium cepa L.*)-Salinity-Nicotinic acid-Tryptophan- Macronutrients status.

Introduction

Onion (*Allium cepa L.*) is one from the popular and export crops which ranked third after potatoes and tomato In Egypt. Onion classified as a salt sensitive crop [8]. Salt stress is a major a biotic stress factor that affects almost every aspect of physiological and biochemical processes in plants, resulting in reduction in growth and yield [13, 24] mentioned that the general effect of salinity is to reduce the plant growth, this resulted in short stem, lower number and leaves. [11]stated that salinity inhibits plant growth by affecting water absorption and biochemical process. They processes such as photo synthesis and carbohydrate metabolism[16]**;** protein synthesis[11] and oxidative defense.[1,26] noticed that onion is classified as a sensitive salt crop that has 1.2 dS/m electrical conductivity threshold. Many authors reported the effect of salt stress on mineral status of different plant: [27,17,19]and [22,13]and [25]. Application of bio-regulators or antioxidant substances were studied by many authors among of them: [5, 16] and [20, 21,23, 7] and [22, 15, 3] and [23] showed that these chemicals improved growth and mineral status of plants and increased the amelioration of salt stress in plants as mentioned by: [3] and [18]. [28] reported the role of amino acids in a biotic stress resistance. Amino acids play an important role in plant metabolism and are essential for protein content; also they reported the role of sulfur in amino acid metabolism as related to plant stress resistance mechanisms. [10]observed an increase in some minerals K+, Ca^{2+} and Mg^{2+} in wheat plant tissues by tryptophan treatment. Therefore, this work aimed to evaluate the mineral status of onion plants as affected by amino acid spraying and salinity.

Material and Methods

A pot experiment was conducted in a greenhouse at the National Research Centre, Dokki, Cairo, Egypt during 2013 and 2014 winter season. Metallic pots (35 cm diameter, 50 cm depth) were used. The inner surface of the pots was coated with three layers of bitumen to prevent direct contact between the soil and the metal. Two kg of gravel (2-3 cm diameter) was placed at the bottom of the pot, followed by 30 kg of air dried clay loam soil(sampled from 40 cm depth from Giza governorate lands).Physical and chemical analysis of soil samples was followed according to [9] and illustrated in Table (1).

Table (1):Some physical and chemical characteristics of the soil used in this study.

A- Soil mechanical analysis.

Soil texture	Clay <2µ %	Silt 200-2 µ %	Fine 200-20 µ %	Course >200 µ %
Clay loam	46.5	21.5	22.2	9.8

B- Soil chemical analysis

Soluble anions Meq/100g soil				Soluble cations Meq/100g soil				OM %	$CaCO_3$ %	EC dSm^{-1}	pH 1:2.5
SO^{--}_4	Cl^-	HCO^{-}_3	CO^{--}_3	Mg^{++}	Ca^{++}	K^+	Na^+	0.97	2.43	2.21	7.87
3.79	1.96	0.94	0.0	1.24	2.58	0.44	2.43				

Available micro-nutrients ppm				Available macro-nutrients%		
Cu	Mn	Zn	Fe	K	P	N
3.98	8.6	3.8	4.9	0.98	0.19	0.76

Onion (*Allium cepa L.*) cultivar Bihari Red seedlings were transplanted to the pots on Dec 1, 2013 and 2014. Soil in each pot received 3 g calcium super phosphate (6.8%P) and 1.5 g potassium sulfate (40.3%K) i.e. equivalent to 106, and 212 kg/ha of P, and K, respectively. Nitrogen was applied as ammonium sulfate (20.5 % N) at 6.86 g / pot, i.e. 488 kg/ha in two equal doses, 2 and 4 weeks after transplanting. All pots were irrigated using tap water during the first 21 days. Subsequently the salt water irrigation began. The treatments included:

1) Main Treatments: Irrigation using tap water or two dilute sea water, i.e. the salt concentrations were 300 ppm (tap water), 3000, and 6000 ppm. In the salt water irrigation treatments, each irrigation with salt water was followed by two irrigations of tap water. Subsamples of the tap water analyzed is given in Table 2.

Table (2): Chemical analysis of sea water used in irrigation.

Source	pH	EC dSm-1	Soluble cations (mM)				Soluble anions(mM)				Total soluble salts mg/L
			Ca^{++}	Mg^{++}	K^{+}	Na^{+}	SO_4^{--}	Cl^{-}	HCO_3	CO^{--}	
Sea water	7.94	50	10.0	56.0	9.70	475.0	28.0	536.0	2.30	2.50	32.0

2) Sub-treatments: Foliar spray of either tryptophan (200 ppm) or nicotinic acid (200 ppm) as compared to only tap water spray (control). The above sprays were done on 21 and 35 days after planting. On 60 days after planting, plant height was measured, and number of leaves per plant was recorded. The plants were harvested 90 days after planting. The bulb and top fresh weights, and bulb diameter were measured. The bulb and tops were sliced into small pieces, dried at 70 ^{o}C for 48 hours. The bulb, leaves and whole plant dry weights were also recorded.

Dry matter digestion and macronutrients determination were done using the methods described by [9]

Statistical significance of the response data were evaluated by analyses of variance (ANOVA) and mean separation tests [29]**.**

Result and Discussion.

- **Response of macronutrients concentration to amino acids application**

Table (3) and figure (1) showed the response of macronutrients concentration and uptake to antioxidant application, showed a negative relationship was detected between salinity level and N, P, K and Ca concentration and the opposite was true for Na concentration. The concentration of Mg decreased by the first level of salts and tended to increase with the second level of salts but still less than that in control plants. The highest concentration of N and Mg was obtained by spraying nicotinic acid while P and Ca was by spraying tryptophan but for Na and K it was in control plants. The highest content of macronutrients was shown by application of nicotinic acid except for Ca it was by tryptophan application. The application of antioxidant increased Ca concentration and decreased the Na concentration under different salt stress level used. [28] reported the role of amino acids in abiotic stress resistance. Amino acids play an important role in plant metabolism and are essential for protein content, also they reported the role of sulfur in amino acid metabolism as related to plant stress resistance mechanisms. [10] observed an increase in some minerals K^{+}, Ca^{2+} and Mg^{2+} in wheat plant tissues by tryptophan treatment. Therefore, this work aimed to evaluate the mineral status of onion plants as affected by amino acid spraying and salinity.

Table(3): Response of macronutrients concentration to antioxidant application.

Antioxidant	Macro nutrients %					
	Na	Ca	Mg	K	P	N
Tap water	0.64	1.87	1.48	1.59	0.46	2.03
Tryptophan	0.58	2.00	1.56	1.39	0.40	2.15
Nicotinic acid	0.50	2.08	1.20	1.45	0.49	2.11

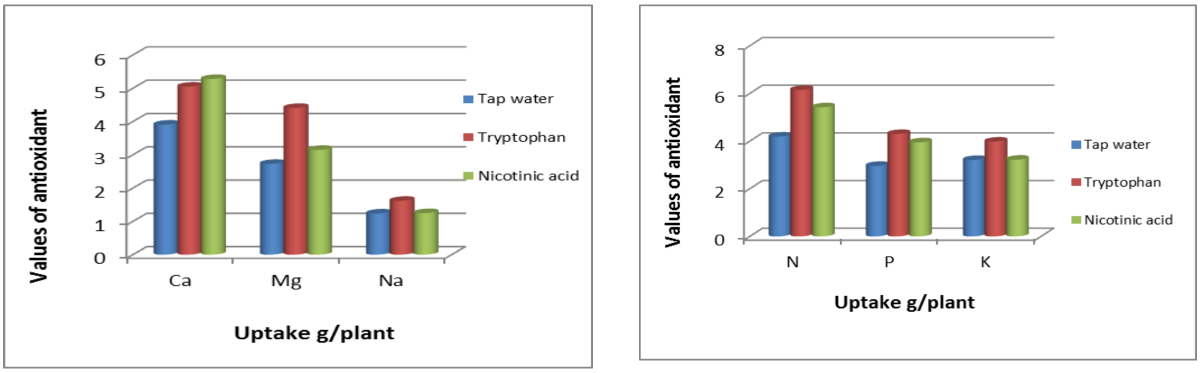


Fig (1)Response of macronutrients uptake to antioxidant application.

- **Salt stress**

Data in Table (4) and figure (2) showed that N and Ca concentration and uptake decreased parallel to the increased of salinity while K concentration decreased on by the high salinity level but P concentration increased with the subjection of onion plants to the first level of salinity and tended to decrease with the high level of salinity to be less than the control. [8] concluded that as NaCl concentration increased plant growth reduction were more pronounced as a result of increased Na and Cl ions content. They added that K ions decreased and S content was linearly lowered by the increase in salt concentration**.** [4] reported that all mineral content of tomatoes affected by salinity. Ionic toxicity promotes an in balance of absorption of essential nutrients [30]. Salt stress also caused alteration in K+/Na+ and other nutrients [31].

Table(4): Response of macronutrients concentration to salt stress condition

Salinity	**Macro nutrients %**					
	Na	Ca	Mg	K	P	N
Tap water	0.39	2.37	1.50	1.57	0.35	2.37
3000	0.50	1.92	1.37	1.56	0.49	2.04
6000	0.75	1.65	1.42	1.27	0.41	1.91

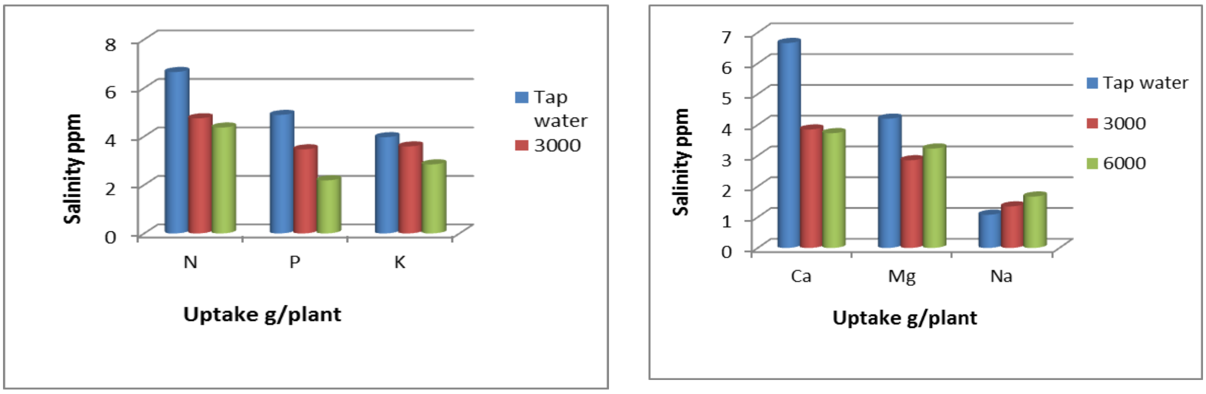


Fig (2): Response of macronutrients uptake to salt stress conditions.

A negative relationship was detected between salinity level and N, P, K and Ca concentration and the opposite was true for Na concentration. The concentration of Mg decreased by the first level of salts and tended to increase with the second level of salts but still less than that in control plants Table(5). All macronutrients content measured in our work were significantly responded except Mg content which the different not great enough to reach the level of significance. This data means that salinity decreased the content and the uptake of most macronutrients but Na content was increased. This may be caused from the effect of salt stress on dry matter accumulation and the lowering of availability of these elements in the soil solution.

Antioxidants

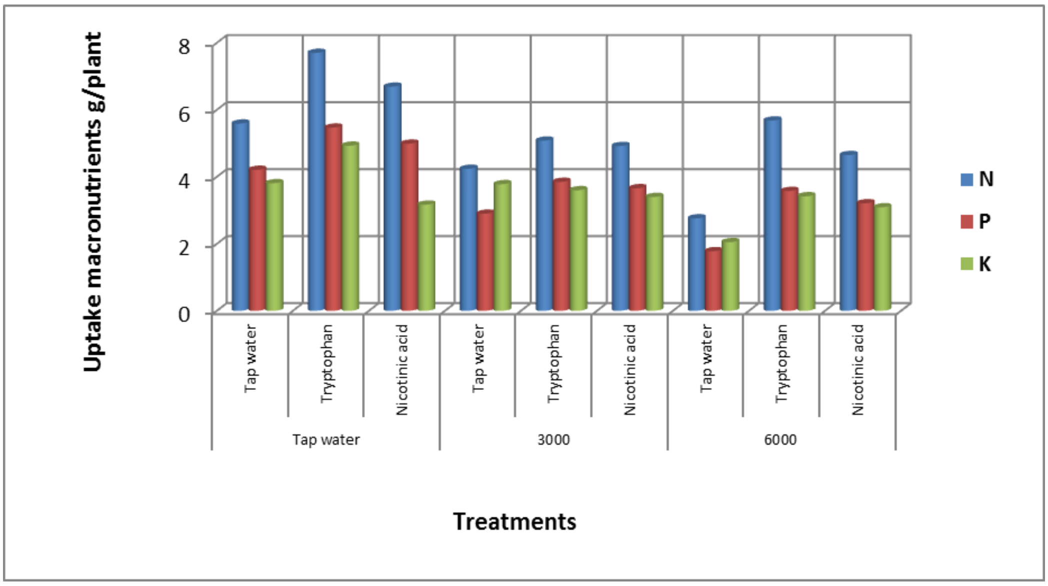
Data in Table (2) showed that the highest concentration of N and Mg was obtained by spraying nicotinic acid while P and Ca was by spraying tryptophan but for Na and K it was in control plants. This date indicated that amino acids increased the content of macronutrients other than Na and the reverse was true for Na content. This may be attributed to the positive effect of antioxidant on the dry matter content and the mobility and translocation of these elements in the plant. Macronutrients were responded significantly to antioxidant treatments except for P content which the differences between the treatments less than to be significant. The highest content of macronutrients estimated in this work was shown by application of nicotinic acid except for Ca it was by tryptophan application (Table 4).

- **Salinity x Antioxidants (Nicotinic acid and tryptophan)**

Data illustrated in Table (5) and Figure (3) showed the interactive effect of salinity levels and macronutrients concentrations. Under irrigation by fresh water, nicotinic acid increased the concentration of N and Mg than tryptophan where the reverse was true for Ca and K concentration compare to the control treatments. Both chemicals decreased the concentration of Na in comparable with the control treatment. Under the moderate salinity, the lesser concentration of K, Mg and Na were obtained by application of tryptophan while for N it was by nicotinic acid but for Ca and P it was by spraying distilled water. Under subjection onion plants to the higher salinity, N, Mg and Ca showed their higher concentrations with nicotinic treatments compare with plants did not received any chemical treatment or tryptophan treatment. For P and Na, the higher concentration was by distilled water. This date proved that application of antioxidant increased Ca concentration and decreased the Na concentration under different salt stress level used.

Table (5): Response of macronutrients concentration to antioxidants application under salt stress condition.

Salinity ppm	Foliar spray antioxidants	Macro nutrients %					
		Na	Ca	Mg	K	P	N
Tap water	Tap water	0.45	2.27	1.62	1.50	0.27	2.21
	Tryptophan	0.39	2.31	1.66	1.55	0.34	2.42
	Nicotinic acid	0.32	2.54	1.22	1.67	0.45	2.37
Tap water	Tap water	o.66	1.69	1.49	1.86	0.46	2.09
	Tryptophan	0.58	2.02	1.53	1.41	0.49	1.99
	Nicotinic acid	o.51	2.06	1.09	1.41	0.51	2.04
Tap water	Tap water	0.80	1.63	1.33	1.32	0.64	1.78
	Tryptophan	0.76	1.66	1.48	1.22	0.38	2.03
	Nicotinic acid	0.68	1.65	1.45	1.28	0.51	1.93



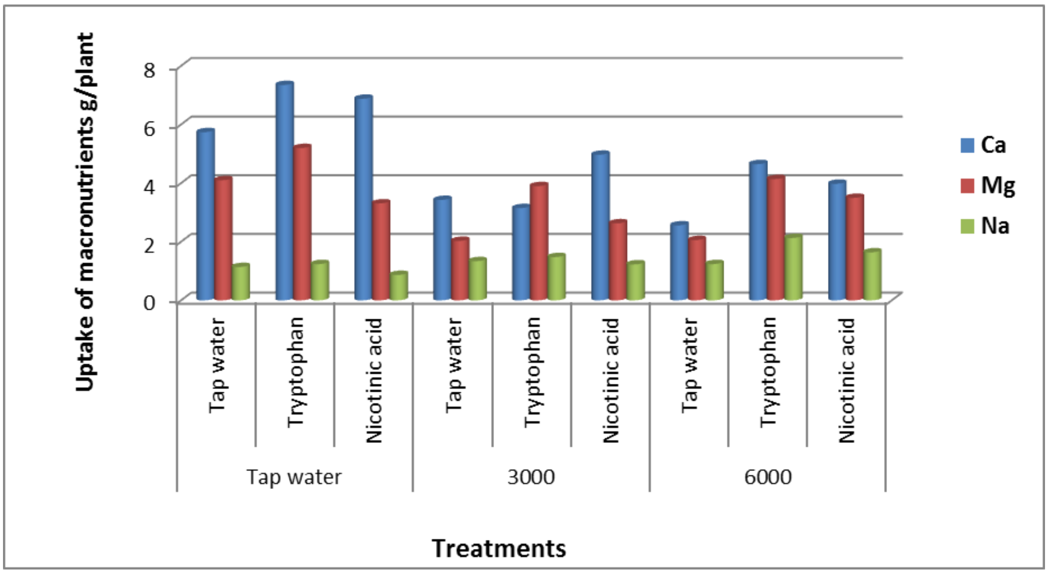


Fig (3) Response of macronutrients uptake to antioxidants application under salt stress condition.

The interaction effect of salinity and antioxidant on macronutrients uptake were presented in Table (5). Data showed that generally application of these two compounds improved the content of macronutrients under different salts concentration in water of irrigation. Concerning the effect of interaction of salinity and antioxidants on content of macronutrients, the nicotinic acid treatment induced the high effect on N ; P; Mg and K contents. Mg under irrigation by fresh water and Na under irrigation either by fresh water or moderate saline solution showed the same response of NPK contents. Ca under irrigation by fresh water higher in the control treatment which sprayed by distilled water and under moderate salinity it was by tryptophan. This may be due to its effects on different physiological processes and this consequently reflected on dry matter content. Nicotinamide (Nicotinic acid amide, viut.B3/niacin) is an individual of vitamin B group involved in many oxidation/ reduction processes in the plant tissues. [6] noted that the treatment with nicotinamide increased the nutrients concentrations of plants grown under salinity. [2] in study for measuring the role of nicotinamide in alleviating the deleterious effects of salinity of faba bean reported that nicotinamide decreased N content and improved the uptake of P, K, Mg, Fe, Zn, Mn and Cu of faba bean plants.

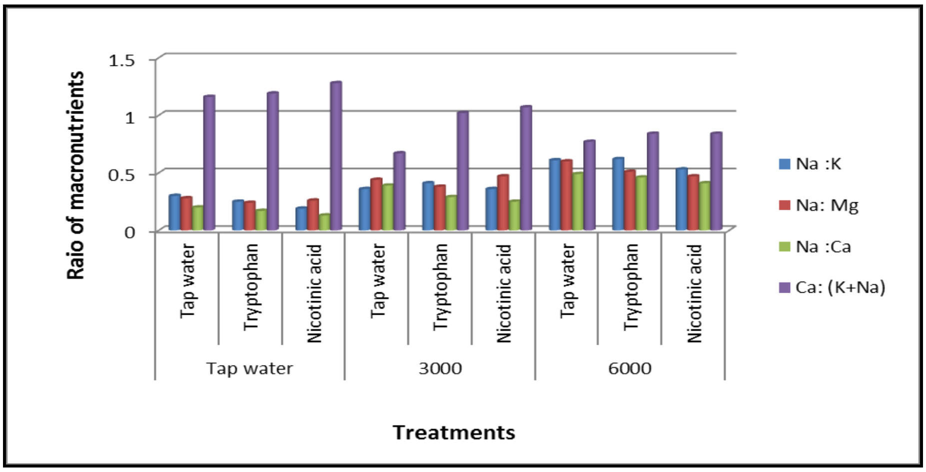


Figure 4: Ratios between sodium and mineral nutrients in onion plants grown under saline condition and treaded with antioxidants

Data in Fig (4) pointed out that The ratios of Na/K, Na/Ca and Na/Mg increased with salinity compare to its values under tap water irrigation while the Ca (Na+K) reversely responded. Concerning the effect of antioxidants, Na : K decreased remarkably with antioxidant spraying under tap water and 6000 ppm salt solution however, under 3000 ppm its slightly affected. The same response of Na: Mg under 3000 and 6000 ppm salt solution. Furthermore, Na : Ca ratio gave the similar trends under 3000 ppm solution as well as under irrigation by tap water. In addition, Ca:(Na+K) only raised by antioxidants under irrigation by water contains 3000 ppm, and the increment with nicotinic acid slightly more than that with tryptophan. There is evidence for a relationship between potassium and sodium uptake and performance under salinity. [7] reported that all onion cultivars under study showed strong linear correlations between K/Na in leaves and grain yield. The most sensitive cultivars showed lowest K/Na ratios and strongest yield reduction. [12] revealed that the Na/K, Na/Mg and Na/Ca were higher under salt stress plants due to the high Na accumulation ions.

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