Mineral Balance of Okra *Abelmoschusesculentus* (L.) Under Salt Stress and Growth Regulators

Fatima Bensaida*, Asma Achour, Moulay Belkhodja and Salma Bensalem

Laboratory of Plant Physiology. Department of Biology. Faculty of Nature and Life Sciences, Oran 1 University, Ahmed Ben Bella.1524, El M'Naouer, 31000, Oran, Algeria.

* E-mail: bensaidafatima@hotmail.com

Abstract

Saline stress develops specific adaptation strategies in plants to restore ionic and nutritional balance. The aim of this experiment is to find out the mineral balance of okra (*Abelmoschus esculentus* L.) under salt stress combined with kinetin (Kn) and salicylic acid (SA). Exogenous intake of kinetin and salicylic acid (0.5mM, 0.1 mM respectively) is by spray and plants are irrigated with NaCl at 100 and 200 mM.l-1 with Hoagland solution (1938). After 122 days, a cationic analysis of the leaves and roots is carried out by ICP-A for Na^+, K^+, Ca^{2+} and Mg^{2+}. Results indicate that the exogenous application of the growth regulators attenuates the effect of the NaCl stress at 200 mM, by reducing the Na^+ amount and increasing the one of K^+ in leaves, while the hormonal combination gave no positive effect under the same NaCl treatment (200 mM).

Keywords: Kn, Mineral contents, Okra, SA, salt stress.

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Introduction

Climate change has been observed around the world for the last 50 years, it is one of the emerging factors in West Africa and perceptible in the problems of agricultural development (I.P.O.C Change, 2014).

Global warming, caused by greenhouse gas emissions, has significant repercussions on the environment (Rosenzweig, et al.2007) and therefore on agricultural yield (Fisher, et al.2010). Plants are exposed to this unfavourable environment, like soil and water salinity, which are the main abiotic constraints that affect plants growth and limit their productivity (Baatour, et al. 2004; Munns and Gilliham, 2015) and agricultural yield (Zahedi, et al. 2012; Munns and Gilliham, 2015).

More than 20 million ha of land is lost each year due to the salinity of the soil in the world (Hamed, et al. 2018). Over 800 million ha are affected by salinization on a global scale. (FAO and ITPS, 2015).

At the cellular level, salt stress mainly results due to the accumulation of toxic ions which causes a nutritional unbalance due to an excess of certain ions (Souguir, et al. 2013; Nimir, et al. 2015; Flowers, et al. 2015). In fact, sodium disturbs cations absorption such as K^+, $Ca^{2\cdot}$ (Iqbal and Ashraf, 2013; Slama, et al. 2015; Volkov, 2015 a, b); at roots level, Na^+ displaces calcium from the cells walls (Volkov, 2015 a, b; Feng, et al. 2018).

The proportional ionic unbalance induced by salt directly and / or indirectly affects several physiological and metabolic processes reflected at plant level by inhibiting their growth (Römheld, 2012; Nimir, et al. 2015; Zörb, et al.2019).

Plants tolerance to salt stress is not a simple phenomenon; it's a consequence of the physiological (Negrão, et al. 2017) and biochemical (Gupta and Huang, 2014; Souguir, et al. 2018) interactions which differ according to the category of plants (Safdar, et al. 2019). Among the plants which have adapted to salt stress, there are the excluder plants which do not accumulate Na^+ in the aerial parts, and includer plants capable of accumulating this cation in the aerial parts and use it for the regulation of the cellular osmotic potential (Shabala, 2013; Maathuis, 2014Maathuis, et al. 2014). Among the mechanisms of tolerance to salinity there is the potassium selectivity (Ordoñez, et al 2014; Isayenkov and Maathuis; 2019).

To mitigate abiotic stresses, plants induce the production of phytohormones; endogenous oligodynamic substances, vectors of information, and which are essential for plants survival. Phytohormones are important for moderating physiological and molecular responses (Peleg and Blumwald, 2011; Wani, et al. 2016). Moreover, hormonal crosstalk leads to synergistic or antagonistic interactions which play a crucial role in plants' response to stress. (Harisson, 2012; Verma, et al. 2016; Sharma, et al. 2019).

There are many agents that act as an assigned transducer in response to stressful conditions; among them salicylic acid (SA), a well-known signalling messenger, able to reduce symptoms of environmental stress in plants (Hayat, et al. 2010; Janda, et al. 2017; Hernández-Ruiz and Arnao, 2018; Koo, et al. 2020). SA regulates various aspects of plants' response to stress through crosstalk by signalling the other hormones (Jayakannan, et al. 2013; Verma, et al. 2016).

The exogenous contribution of SA has been suggested as a potential mechanism of salt tolerance in plants, by the accumulation of osmolytes, maintaining an optimal Na^+/K^+ ratio, and the strengthening of antioxidant protection (Hayat, et al. 2010; Ahanger, et al. 2017). In addition to SA, other hormonal pathways, notably cytokinins, are activated (Bali, et al. 2017). Kinetin is a synthetic compound analogous to cytokinins known for their crucial role on the regulation of cell division and its growth, chloroplast development, nutrients mobilization, and delaying the senescence (Fahad, et al. 2014; Kieber and Schaller, 2018; Wybouw and Rybel, 2019). In salt stress conditions, kinetin improves plant resistance by reducing the endogenous level of ABA, (Hamayun, et al. 2015) and promoting the gibberellins and salicylic acid synthesis (Wani, et al. 2016; Atia, et al. 2018).

The objective of this study is to describe the effect of salinity under an exogenous foliar supply of salicylic acid and kinetin, on the cationic distribution of Na^+, K^+, Ca^{2+} and Mg^{2+} in okra *Abelmoschus esculentus* L.

Material and Methods

Experimental device

Okra seeds are disinfected with 8% sodium hypochlorite for 5 min, and then rinsed with distilled water several times; seeds are soaked for 2 hours in distilled water then placed in petri dishes on top of a layer of moisturised filter paper, and maintained in a culture chamber set at 25 ° C.

Seeds are subjected to a saline and hormonal treatment according to the following combinations: NaCl 0 mM+ 0 Hormone; NaCl 0mM+ kinetin [0.5 mM]; NaCl 0 mM + salicylic acid [0.1 mM]; NaCl 0 mM+ kinetin / salicylic acid (0.5/0.1); NaCl at 100 mM+ kinetin (0.5); NaCl at 100 mM + salicylic acid (0.1); NaCl at 100 mM + kinetin / salicylic acid (0.5/0.1); NaCl 200 mM+ kinetin (0.5); NaCl at 200 mM + salicylic acid (0.1); NaCl at 200 mM+ kinetin / salicylic acid (0.5/0.1). After a week of germination, the seedlings obtained under salt and hormonal treatment are transplanted into pots at the greenhouse, until the end of their 16-week cycle (122 days).

As at the germination stage, the seedlings continue to receive the same saline and hormonal treatment with the same combinations from the 3rd week. The concentrations of the saline treatment are the same applied at the germinative stage [0, 100, 200 mM NaCl]. From the 3rd to the 7th week the application of the saline treatment is of two watering per week, and starting from the 8th week, the frequency goes to three watering per week. The exogenous application of growth regulators on leaves is based on kinetin [0.5 mM] and salicylic acid [0.1 mM] and it is done once a fortnight from the 3rd to the 7th week, and one spray weekly is applied from the 8th week until the 16th week (122 days).

Determination of Cations Content in Organs Plant

The vegetable powder 100 mg is added to 5 ml of 65% HNO_3 and 5 ml of 35% H_2O_2 after 24 hours of incubation at 75 ° C, the solution is filtered (Allen, et al. 1986). The filtrate is collected in a flask and then calibrated to 50 ml with demineralized water. The determination of Na^+, K^+, Ca^{2+} and Mg^{2+} is carried out by ICPA (Inductively Coupled Plasma Atomic).

Statistical analysis

The results obtained are subjected to an ANOVA analysis of variance and Pearson correlation matrix using STATISTICA version 12 software to assess the significance of the effects tested with a threshold of $p = 0.05$. The means are compared by the Fisher LSD test to determine the homogeneous groups at $\alpha^{<}$ 0.05.

Many authors have tackled leadership from multiple standpoints including title, position, and authority. However, the purpose of this study is to magnify leadership from the communicative, interactive perspective. Thus, this paper affirms communication as a function of language while adopting approaches of Howard Gardner and John Maxwell as explained below. This study, besides acknowledging the communicative role of language, conceptualizes the notion of a leader being any person who simply may influence others, a notion that is aligned with Gardener's and Maxwell's points of views as well.

Gardner claims that a leader can be anyone affecting or influencing others. He has depicted leadership through the use of embodiment and storytelling. He emphasizes that a leader need not be in a managerial or political position. In fact, he asserts that "a leader is an individual (or, rarely, a set of individuals) who significantly affects the thoughts, feelings, and/or behaviors of a significant number of individuals" (Gardner, 1995). Uniquely, Gardner (1995) embraces a cognitive understanding to leadership that essentially begins in the human mind (p. 15).

Maxwell, however, considers leadership to have evolved from the traditional sense of authority and control. He highlights perceptions of leadership back in the day as compared with that of today. He relates, "People think they need to be appointed to a position of leadership, when the reality is that becoming a good leader requires desire and some basic tools (Maxwell, 2018, p. 2). Maxwell (2018) asserts the influence the leader makes on others, while James Georges affirms that "Leadership is the ability to obtain followers"

Results

Note: the salt controls (100 and 200 mM NaCl) are withdrawn from the protocol of adult plant phase following a very weak germination at 100 mM and no germination at 200 mM of NaCl.

Effect of hormones and NaCl on cations by organ

- **Effect of kinetin**

The graphs (figure.1 A, a) represent the effect of kinetin on cations accumulation (Na^+, K^+, Ca^{2+} and Mg^{2+}) in leaves and roots respectively, of plants stressed with NaCl.

The comparison of Na+ contents in leaves and roots shows that Na+ accumulation in leaves is much lesser than the one observed in roots. The exogenous supply of kinetin during the plants' growth have a significant effect on the accumulation of sodium in both organs, the aerial and root parts enriched more in Na+ during the intensification of salt treatment. We observed a concentration of 10.06 ppm in leaves at 200 mM of NaCl, and 70.65 ppm in roots. The statistical study demonstrates a highly significant effect of kinetin on the accumulation of K^+ (table1). In fact, it accumulates more K^+ with salt stress in leaves until it reaches a concentration of 107.66 ppm under 200 mM of NaCl. On the other hand, the roots slowly loses its potassium rate under salt stress, the control T registers a value of 60.79 ppm and only 51.39 ppm under 200 mM of NaCl.

The results are illustrated in graphs (A, a), and according to witnesses, the accumulation of Mg^{2+} is balanced between the two organs. The exogenous contribution of kinetin maintains a significant Mg^{2+} content in roots. According to the ANOVA test at $p < 0.05$, kinetin has a highly significant effect on the accumulation of Mg^{2+} in the leaves and roots (Table.1). Ca^{2+} is more accumulated in leaves then roots (graphs, A, a), the statistical test reveals a highly significant effect of the exogenous application of Kn alone or in combination with salt for both organs, at 200mM of NaCl, Ca^{2+} content is 10.26 ppm in the leaves and 3.74ppm in roots.

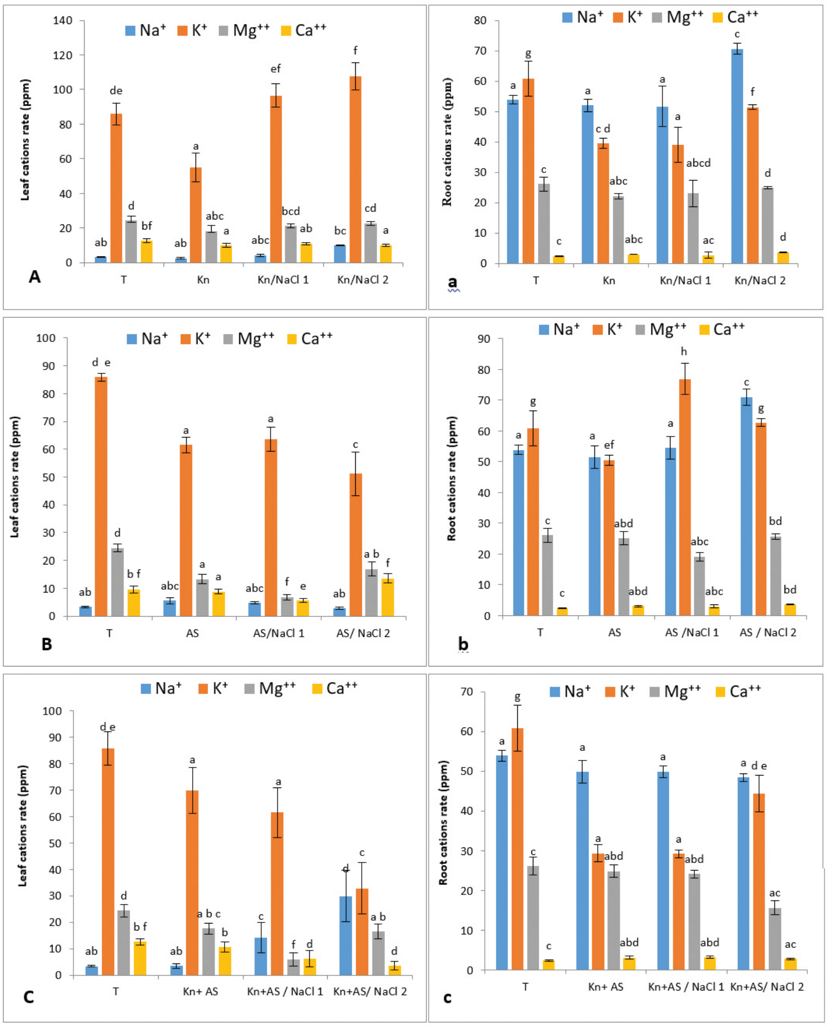

Figure 1: *Growth regulators & NaCl effect on cations accumulation in leaves & roots of Okra (Abelmoschusesculentus L.) – (A-a): Kinetin effect. – (B-b): Salicylic acid effect. – (C-c): The combination of Kinetin & Salicylic Acid effect.*

- **Effect of salicylic acid**

The graphs (figure.1 **B**, **b**) represent the effect of SA on the accumulation of cations (Na^+, K^+, $Ca^{2+}$and Mg^{2+}) at leaves and roots levels respectively. The Na^+ content in roots increases simultaneously with NaCl concentrations in watering solution, this cation registers a value of 71 ppm at 200 mM of NaCl.

In leaves, Na^+ rates are close for all treatments, according to the statistical test at $p < 0.05$ salicylic acid alone has a significant effect on Na^+ accumulation, but when combined with salt, SA loses its effect. On the other hand, SA has a highly significant effect on Na^+ in roots, whether applied alone or combined with NaCl.

The statistical study reveals that the exogenous supply of SA alone has no effect on the accumulation of K^+ in the aerial part, but its application on stressed plants demonstrates that it has a significant effect. For roots, SA has a highly significant effect on K^+ content whether applied alone or combined with salt, this is confirmed by the graphs (**B**,**b**). In leaves, K^+ content decreases when salt treatment increases, in the roots level K^+ content reaches 76.88 ppm under 100 mM NaCl then decreases to 62.68 ppm when NaCl is at 200mM.

SA decreases the accumulation of Mg^{2+}in leaves, the content is 24.47 ppm for the control and 6.84 ppm for plants treated with 100 mM NaCl; but at 200 mM NaCl, Mg^{2+} content goes back to 16.96ppm. At the root level, Mg^{2+} contents record close values for all the treatments. The result of the statistical study shows that the applied SA alone has no significant effect on the accumulation of Mg^{2+} in leaves, but salt combined with SA is highly significant. For roots, the exogenous supply of SA has a highly significant effect on Mg^{2+} contents on control and stressed plants (Table.1).

Ca^{2+} contents for all treatments in roots are very low and do not exceed 3.64ppm, for the aerial part Ca^{2+} switches from 5.58 ppm in the 100mM treatment NaCl to 13.60ppm under 200mM NaCl combined with SA. According to the statistical test, SA alone has no significance on the accumulation of Ca^{2+} in leaves but once combined with salt its effect increases (p = 0.0**). But for roots, SA either alone or in combination with salt, has a highly significant effect (Table 1).

Table 1: *Two-factor analysis of variance (ANOVA) for the cations content of okra plants (Abelmoschusesculentus L.)*

		Na^+		K^+		Ca^{++}		Mg^{++}	
		P	F	P	F	P	F	P	F
NaCl	L	0.024*	4.33*	0.0**	9.38*	0.0**	36.9*	0.0**	31.5*
	R	0.0**	15.9*	0.0**	16.4*	0.0**	8.7*	0.0**	27.8*
SA	L	0.0**	11.6*	0.83	0.041	0.13	2.43	0.13	2.3
	R	0.0**	73.4*	0.0**	161.5*	0.0**	77.6*	0.0**	42.5*
Kn	L	0.0**	16.4*	0.0**	49.03*	0.0**	15.1*	0.0**	43.5*
	R	0.0**	65.5*	0.01*	6.94*	0.0**	66.08*	0.0**	30.6*
NaCl*SA	L	0.15	2.01	0.02*	4.09*	0.0**	10.04*	0.0**	11.6*
	R	0.0**	23.9*	0.0**	103.1*	0.0**	9.08*	0.0**	9.1*
NaCl *Kn	L	0.0*	8.5*	0.0**	24.6*	0.0**	18.6*	0.0**	14.07*
	R	0.0**	20.4*	0.0**	61.9*	0.0**	9.19*	0.0**	15.9*
SA*Kn	L	0.09	3.07	0.0**	64.5*	0.0**	88.3*	0.0**	31.8*
	R	0.0**	174.6*	0.0**	331.6*	0.0**	95.6*	0.0**	52.1*
NaCl *SA*Kn	L	0.18	1.82	0.0**	44.1*	0.0**	58.9*	0.0**	28.8*
	R	0.0**	51.9*	0.0**	84.9*	0.0**	18.8*	0.0**	27.2*

L: leaves; R : roots P & F values of two factors (ANOVA)

*Significant difference at $p<0.05$ **Highly significant difference at $p<0.05$

- **The hormonal combination effect**

The graphs (figure.1 **C**, **c**) represent the combined effect of salicylic acid and kinetin on the accumulation of cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) in leaves and roots respectively. With the intensification of salt stress, the content of K^+ and Ca^{2+} in leaves decreases. Conversely to Na+, its content increases with salt stress; it varies between 3.32 ppm in witnesses and 29.89 ppm at 200 mM of NaCl. The level of Na+ and Ca^{2+} is stationary in root, K^+ decreases at both (SA /Kn) + 0 mM of NaCl and (SA /Kn) +100 mM of NaCl, then it increases under 200 mM of NaCl with 44.29 ppm.
The Mg^{2+} content is more important in roots than leaves. This cation is reduced under the evolution of salt stress in both organs. However, the concentration of Mg^{2+} increases to 16.48ppm at 200mM of NaCl in leaves . The statistical study reveals that the hormonal combination has no effect on the accumulation of Na^+ for leaves even for stressed plants. In contrast, at the root level the combination of Kn /SA used alone or with NaCl has a highly significant effect on the accumulation of Na^+. K^+, Ca^{2+} and Mg^{2+}. The exogenous supply of the combination Kn /SA alone and under salt stress has a highly significant effect on mineral accumulation and this is for both organs (Table1).

Discussion

This study of okra, under salt stress with an exogenous supply of kinetin and salicylic acid, demonstrates a significant accumulation of Na^+ in roots, compared to leaves under both hormones. K^+ is more accumulated in the leaves of plants treated with kinetin, but in plants receiving SA, the rate of K^+ is higher in roots. In plants treated with the combination of kinetin and SA under salt stress, Na^+ migrates to the leaves, while K^+, Ca^{2+} and Mg^{2+} decrease in the same organ. Okra seems to express an excluder character; the exclusion of Na^+ is achieved by the combined action of a series of salt overly sensitive protein “SOS “ to reduce the accumulation of Na^+ in the aerial part (Quan, et al. 2007; Shabala, 2013). It is found that there is a positive correlation between the exclusion of salts and salt tolerance in several species (Munns and Taster, 2008; Adolf, et al. 2013; Bertazzini, et al. 2018).
Our results corroborate with Nimir, et al. (2016), they say that the exogenous application of SA is the best treatment that reduces membrane permeability and the concentration of Na^+ and increases the concentration of K^+ in the leaves of sweet sorghum under salt stress.
Gurmani, et al. (2018) found that kinetin pre-treatment is more efficient than SA, but the exogenous supply of both hormones increases the photosynthesis by reducing electrolyte leakage and increases chlorophyll pigments, dry biomass and the accumulation of Na^+ and K^+ in cucumbers. The role of kinetin on growth and biomass yield under unfavorable conditions has been reported in several species as soybeans, beans and tomatoes. (Hamayun, et al. 2015 ; Al-Taey, et al. 2018 ; Ahanger, et al. 2018). According to Zwack and Rashotte, (2015) maintaining a homeostatic concentration of the active form of cytokinin would be an important component in the response to salt stress. Cytokinin is involved in this response by controlling leaf growth and senescence probably through regulation of K^+ transport (Wang, et al. 2019). Argueso, et al. (2009) demonstrated that endogenous level and transport of cytokinin decreases in several species of plants in salt conditions. Cytokinin plays an important role in the growth and development of leaves by the initiation and maintenance of S-Adenosyl L-Methionine (SAM) which is an important cofactor involved in very many enzymatic processes essential to all living organisms (Kovács, et al. 2020). The exogenous supply of kinetin is involved in regulation and management of the time of leaf senescence (Iqbal, et al. 2017).

SA has been the subject of several studies which confirm and approve its effectiveness against salt stress in different species as Corn (Gunes, et al. 2007), Tomato (He and Zhu, 2008), Mung bean (Khan, et al. 2010), Wheat (Kang, et al. 2012), Barley (Fayez, et al. 2014), Arabidopsis (Jayakannan, et al. 2013), Soy (Ahmad, et al. 2014), Peanut (Jaiswal, et al. 2014; Kong, et al. 2014), Rice (Jini, et al. 2017), Safflower (Shaki, et al. 2017,2018,2019).

Khan et al. (2010) demonstrate that the exogenous spray of SA on Mung bean increases the rate of K^+ and decreases Na^+ in the cytosol, regulating the expression and activity of K^+ and Na^+ transporters and H^+ pumps which generate the driving force for their transport. Furthermore the accumulation of Ca^{2+} in the treated plants by SA allows the integrity of the membrane and reduces the toxic effect of Na^+ and Cl^-, because salt stress makes the membrane lose its permeability and causes an efflux of K^+ and alters the selectivity of K^+/ Na^+ ratio (Cramer, et al. 1987) . Gunes, et al. (2007) reported that the application of SA increased the biomass and the concentrations of the following minerals as Ca^{2+}, Cu^{2+}, $Mg2^+$, Mn^{2+}, K^+ and Zn^{2+} in corn during salt stress. Kang, et al. (2014) reported that SA is the key to the molecular mechanism in biotic and abiotic stress signalling by the overlaps of the transducers illustrated in the signalling pathways of both stresses. El-Katony, et al. (2019) suggest that the timing of the exogenous application of SA plays a very big role, in soy's response to salt stress.

Shaki, et al. (2019), after several experiments on the exogenous application of SA, found that the Safflower tolerates salt stress by overexpressing SOS1 gene, just as it induces an increased sequestration of Na^+ in vacuoles via increased expression of the NHX1 gene; the exogenous application of SA increases the level of auxin and decreases that of gibberellins in plants treated with 200 mM of NaCl.

Signalling between cells is very fast and dynamic, these signals can involve the transport of charged ions which modifies the polarity of the membrane, the intercellular gradients, or the interaction between proteins and phytohormones (Larson, 2019).

Calcium is the second major messenger of the transduction pathways in plants where it is kept in low concentration in the cytosol by mechanisms of extrusion and sequestration in the organelles; it allows the formation of calcium signals (Mc Ainsh and Pittman, 2009). ABA activates the calcium signalling pathway responsible for the activation of several genes which control the response to abiotic stress (Harrison, 2012). Calcium sensors target the transduction proteins involved in the regulation of signalling pathways such as protein kinases of the Salt Overly Sensitive pathway and K^+ transport channels to maintain its absorption in the root. The exclusion of Na^+ by SOS3 pathway is expressed only in the root level (Boudsocq, 2010; Sathee, et al. 2015; Liu, et al. 2020). CPK-dependent Ca2+ (calcium protein kinases) is the key to an integration mechanism between SA signalling and ABA signalling in guard cells (Prodhan, et al. 2018). Ion transport plays a key role in the regulation of stomatal movements which is notably controlled by ABA signalling (Lim, et al. 2015; Cai, et al.2017; Eisenach and De Angeli, 2017), and SA signalling (Prodhan, et al. 2018); ABA is inhibited by exogenous application of SA (Grzyb, et al.2018).

The crosstalk between phytohormones is a complicated phenomenon involving at the same time the precursors and antagonists of the same hormone (Yuan, et al. 2019).

Gaspar, et al. (2016) cite that the plant trauma is caused by exogenous "hormones", or growth regulators; they explain the complexity of controlling the metabolisms of the real "phytohormones" synthetized by the plant and their decisive role which may arise from a favorable or unfavorable physiological state to the interconnected processes of plant growth and development.

Table 2: *Pearson correlation matrix between NaCl, SA, Kn, and the mineral contents in leaf (L) and root (R) of Okra (Abelmoschusesculentus L.)*

	NaCl	SA	Kn	+L Na	+R Na	+L K	+R K	L Mg+2	R Mg+2	L Ca+2	R Ca+2
NaCl	1,00	0,00	-0,00	0,30	-0,079	-0,24	-0,09	-0,21	*-0,35	-0,32	-0,12
SA		1,00	0,00	*0,36	*0,33	-0,01	*0,38	-0,09	*0,35	0,08	*0,46
Kn			1,00	*0,43	**0,36	*0,40	-0,07	*0,39	*0,34	0,19	*0,43
+L Na				1,00	0,22	0,12	0,13	0,25	0,11	-0,10	0,25
+R Na					1,00	**0,80	**0,83	**0,75	**0,93	**0,82	**0,95
+L K						1,00	**0,61	**0,79	**0,81	**0,80	**0,70
+R K							1,00	**0,55	**0,75	**0,63	**0,76
L Mg+2								1,00	**0,73	**0,82	**0,62
R Mg+2									1,00	**0,86	**0,92
L Ca+2										1,00	**0,71
R Ca+2											1,00

*Significant difference at p˂0.05 **Highly significant difference at p˂0.05

Conclusion

Kinetin and salicylic acid when applied alone confirm their effectiveness in our study, with a decrease in the amount of Na+ in leaves of Okra while K^+, Mg2+ and Ca2+ concentrations increase at the same level under 200 mM of NaCl. However, their combination was less effective; the results on the mineral nutrition of non-stressed plants are good, but under salt stress, the ion balance indicates a severe sensitivity for plants treated with 200 mM.

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التوازن المعدني للبامية *Abelmoschus esculentus* (L.) تحت تأثير الاجهاد الملحي مع إضافة خارجية للكينيتين وحمض الساليسيليك

فاطمة بن سعيدة *، اسماء عاشور ، مولاي بلخوجة وسالمة بن سالم
مخبر فيزيولوجيا النباتات، قسم البيولوجيا، كلية علوم الطبيعة و الحياة، وهران1، جامعة أحمد بن بلة، الجزائر
*بريد الكتروني :bensaidafatima@hotmail.com

المُستَخلَص

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يطور الاجهاد الملحي استراتيجيات تكيف محددة في النباتات لاستعادة التوازن الأيوني والغذائي. والهدف من هذا العمل هو تنفيذ التوازن المعدني للبامية *Abelmoschus esculentus* L. تحت إلاجهاد المالح جنبا الى جنب مع هرمونين او منضمين للنمو: الكينيتين وحمض الساليسيليك، ويتم رشهما على الأوراق بتركيز 0,5mM و0,1mM على التوالي. تسقى النباتات بكلوريد الصوديوم بتركيز200mM وبعد 122 يوم نجري تحليلا معدنيا للأوراق وللجدور بواسطة التحليل الطيفي للانبعاثات الذرية للبلازما المقترنة بالحث ICP-A لكل من: Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}.
المساهمة الخارجية للهرمونات في خفض تأثير وتهوين عوارض الملوحة للبامية عند التركيز 200 mM كانت إيجابية، في حين أن المزج بين الهرمونين لم يعطي أي تأثير إيجابي على النبات سواء طبقت لوحدها او مدموجة مع حمض الساليسيليك.

الكلمات الدالة: البامية، إلاجهاد الملحي، الكينيتين، حمض الساليسيليك، المكونات المعدنية.