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ION ACCUMULATION AND TOLERANCE TO SALINITY IN DIFFERENT CUBAN CHICKPEA CULTIVARS (*Cicer arietinum* L.)

Acumulación de iones y tolerancia a la salinidad en diferentes cultivares cubanos de garbanzo (*Cicer arietinum* L.)

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ABSTRACT. Chickpea (*Cicer arietinum* L.) is considered a species sensitive to salinity, but there are differences in the degree of tolerance to this type of stress. The present study was carried out to determine the tolerance to salinity of some cuban cultivars of chickpea and its relationship with indicators of the development and accumulation of ions in the different organs of the plant. For this, eight chickpea cultivars exposed to two treatments, 0 and 50 mM NaCl, were studied. The results showed that the cultivars Nac-29, Nac-5HA and JP-94 were the ones that showed the highest degree of tolerance to salinity. The cultivar N-29 turned out to be more tolerant and although it diminished its growth, the results show that it also accumulated less quantity of ions in the different organs of the plant, in the two conditions of imposed salinity. Therefore, it can be inferred that the reduction in growth was related to some inability of the chickpea plants to prevent high concentrations of saline ions from reaching the leaves, resulting in considerable variability in the degree of tolerance to salinity the cultivars evaluated.

Key words: biomass, growth, toxicity, tolerant

RESUMEN. El garbanzo (*Cicer arietinum* L.) es considerado una especie sensible a la salinidad, pero existen diferencias en cuanto al grado de tolerancia a este tipo de estrés. El presente estudio se realizó para determinar la tolerancia a la salinidad de algunos cultivares cubanos de garbanzo y su relación con indicadores del desarrollo y la acumulación de iones en los diferentes órganos de la planta. Para ello, se estudiaron ocho cultivares de garbanzo expuestos a dos tratamientos, 0 y 50 mM de NaCl. Los resultados evidenciaron que los cultivares N-29, Nac-5HA y JP-94 fueron los que mostraron mayor grado de tolerancia a la salinidad. El cultivar N-29 resultó ser más tolerante y aunque disminuyó su crecimiento, los resultados evidencian que también acumuló menos cantidad de iones en los diferentes órganos de la planta, en las dos condiciones de salinidad impuesta. Por tanto, se infiere que la reducción del crecimiento estuvo relacionado con alguna incapacidad que tienen las plantas de garbanzo para evitar que altas concentraciones de iones salinos lleguen a las hojas, trayendo como consecuencia una considerable variabilidad en cuanto al grado de tolerancia a la salinidad de los cultivares evaluados.

Palabras clave: biomasa, crecimiento, toxicidad, tolerantes

INTRODUCTION

Abiotic stress, particularly drought and salinity, not only compromises the quality of crops and limits yields, but also restricts planting areas and the viability of crop production (1). These environmental problems in the form of abiotic stress are basically a severe threat to world agriculture (2).

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Currently, salinity is a serious problem and is increasing strongly in many parts of the world, particularly in arid and semi-arid regions (3). More than 74 % of the soils devoted to agriculture worldwide have salinity problems (4) and in many cases the electrical conductivity of the soil exceeds the tolerance index of important economic species (4,5).

The excess of salts in the soil, causes damages in the plants that are related to a specific toxicity, normally associated to the excessive absorption of Na^+ and Cl^-, a nutritional imbalance caused by the interference of the saline ions with the essential nutrients, a water stress that is produced by the decrease of the osmotic potential of the medium and the combination of the effects indicated above (6).

Several methods have been used to reduce the harmful effect of soil salts and increase their agroproductive quality (7-9). Current trends include biological methods and agrotechnical management; among them, the introduction and selection of species and varieties that present levels of tolerance, adaptability and adequate production, which make it possible to replace the most susceptible (9-11).

Chickpea (*Cicer arietinum* L.) is a legume of commercial importance and is consumed due to its nutritional properties, representing a great option, mainly due to its high protein content (12).

In the world, 14.2 million tons are produced annually, in 14.8 million hectares, with a productivity of 0.96 t ha^{-1}, (13), being India the first country in terms of production and productivity.

There are numerous studies about the tolerance to salinity in this crop; however, with respect to the mechanisms involved in tolerance, nothing is clear yet (14). The reproductive phase of the chickpea (15) is more sensitive to salinity than the vegetative phase and it has been shown that, because it is more sensitive to this phenomenon during the flowering period, it creates instability in its development and low productivity (16). Although there are several criteria on the variability of this species to salt stress (14) all expectations have not yet been met, so we will have to continue working on genetic improvement for this character (15,17-20). For this reason, this research was carried out with the objective of determining tolerance to salinity of Cuban cultivars of chickpea, through indicators of the development and accumulation of ions in the different organs of the plant.

MATERIALS AND METHODS

The research was carried out in the room of lights of the Department of Biochemistry and Plant Physiology belonging to the INCA, in the period from May 25 to July 15, 2015, with a photoperiod of 12 light hours and 12 hours of darkness, and a temperature that oscillated between 26 °C during the day and 18 °C at night, according to the demands of the crop. The cultivars evaluated were of the Kabuli type: Nac-29 (N-29), N-5HA, Nac-27 (N-27), Nac-24 (N-24), Nac-30 (N-30), Nac-6 (N-6), of the Gulabi type: JP-94 and one of foreign origin: Blanco Sinaloa-92 (B. Sinaloa-92). All from the germplasm bank of the Institute of Fundamental Research of Tropical Agriculture (INIFAT).

The seeds were previously treated with a solution of TMTD at a rate of 4 g kg^{-1} of seeds, for ten minutes and then washed with sterile distilled water. Subsequently, sterile silica sand was pre germinated at room temperature and four days after germination the seedlings were transplanted for plastic containers with a capacity of 700 g of soil.

These cultivars were subjected to a control treatment and 50 mM NaCl. A solution of NaCl was prepared according to the treatments and applied directly to the plant, at a rate of 50 mL per pot, until drainage.

A completely randomized design was used, with 16 treatments consisting of: chickpea cultivars in non-saline conditions and chickpea cultivars subjected to 50 mM NaCl.

A leached Red Ferralitic soil was used, according to the last genetic classification of soils (21) and an organic matter content of animal origin, with a ratio of 2:1. Stress was imposed 15 days after the germinated seedlings.

At the end of the experiment, measurements of the corresponding variables were carried out:

- Height of the plant (cm): measured from the neck of the base of the stem to the terminal bud with a graduated ruler.
- Number of green and dry leaves: these variables were determined by counting their respective quantities.
- Biomass dried by organs (g $plant^{-1}$): each of the plant organs (leaves, stem, and root) was dried in the oven at a temperature of 80 °C to constant weight and weighed on an electronic analytical balance.
- Ion content in the different organs of the plant: it was determined using the Atomic Absorption Spectrophotometer (Analytik Jena brand, Germany), in the different organs of the plant and a sample of 0.5 g of the dry plant material was taken.

For the processing of the results, a simple classification variance analysis was performed, based on a linear model of fixed effects and in cases where significant differences existed between the means were compared by the Duncan test ($p \leq 0.05$). For the comparison between saline and non-saline treatments, the theoretical distribution of Student probabilities was used for continuous quantitative variables, using a sample size of $n < 30$. For all these analyzes the professional statistical package IBM.SPSS.Statistics version 22 was used. For the construction of the graphs, the statistical package SigmaPlot version 11.0 was used.

RESULTS AND DISCUSSION

As a first approach to study the effects of salt stress and the responses to the tolerance of chickpea plants to salinity, different Cuban chickpea cultivars were exposed under stressful conditions.

The analysis carried out on the height variable of the plant showed the highly significant existence among the varieties before salinity (50 mM). This result evidences the differentiated response of the cultivars, which has an important practical meaning since it allows to select, initially, varieties with tolerance, according to the electrical conductivity of the available soils; and in the medium term, possible progenitors for genetic improvement programs (22).

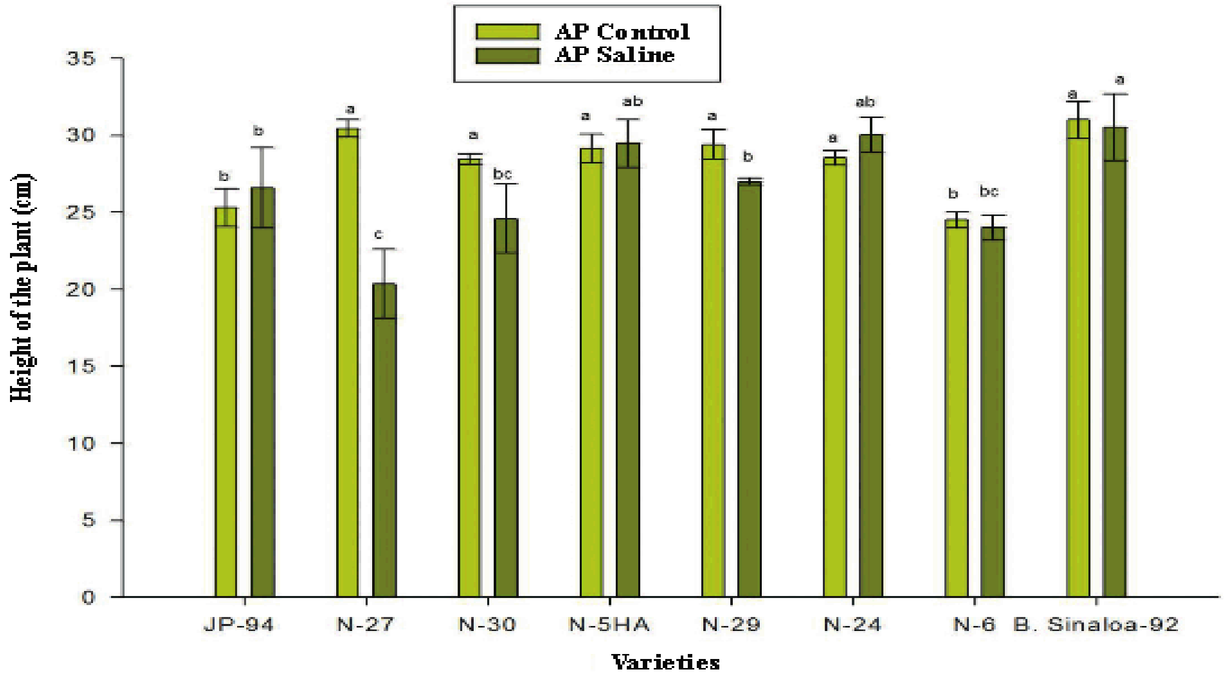
Currently, monitoring the response of available cultivars has been a practical and economically viable alternative to raise the utilization coefficient of saline soils in various regions of the world (23).

When evaluating the differences in the height of the plant in each variety (Figure 1) in the two imposed conditions (0 and 50 mM NaCl) it can be observed that this indicator is one of the most reductions experienced during the investigation period.

In the experimental conditions of the present investigation, none of the cultivars stopped growing during the first 15 days, after taxing the salt stress, almost all the cultivars decreased the growth rate with respect to the control of each variety.

Cultivars N-27, N-30, N-29, were the most impacted by the effect of salinity on this indicator; however, cultivars N-5HA, N-24 and JP-94 were the ones that showed the best response in saline conditions, it should be noted that except for the cultivar Blanco Sinaloa-92, did not show significant reductions in this variable, the variety N-5HA , showed a better growth, with respect to the rest of the cultivars evaluated, since there was no significant reduction in growth.

In the present essay, the reduction of the growth, perhaps it was related to some incapacity that the plants of chick-pea have to avoid that high concentrations of saline ions arrive at the leaves, aspect that has been verified in diverse species.



The vertical bars indicate the standard error of the means for $p \leq 0.05$

Figure 1. Height of the plant (AP) at 35 days of sowing at different levels of salinity (0 mM and 50 mM NaCl)

Enzyme systems of glycolysis are especially sensitive to saline solutions, resulting in reduced energy availability, nutrient acquisition and decreased plant growth (24).

Despite the sensitivity of the chickpea to salinity, particularly in the early stages of development, there are some reports of interspecific variability for this character. The highest levels of salt concentrations in the soil lead to a significant reduction in development and to a loss of yield of between 8 and 10 %, worldwide (25).

Another indicator of great importance that was taken into account to determine the tolerance to salinity, was the number of green leaves and dry leaves, which is evidenced in Figure 2. Previously it could be observed that the N-29 variety reduced a little its growth in terms of height, although this reduction was not significant; however, in these indicators (number of green and dry leaves) it was the one that showed the best response, when compared in the saline treatment, with respect to the control.

In these indicators, cultivars N-29, JP-94 and N-5HA, were the least affected by salts, this being an element that shows that these cultivars could be more tolerant than the rest of the cultivars evaluated.

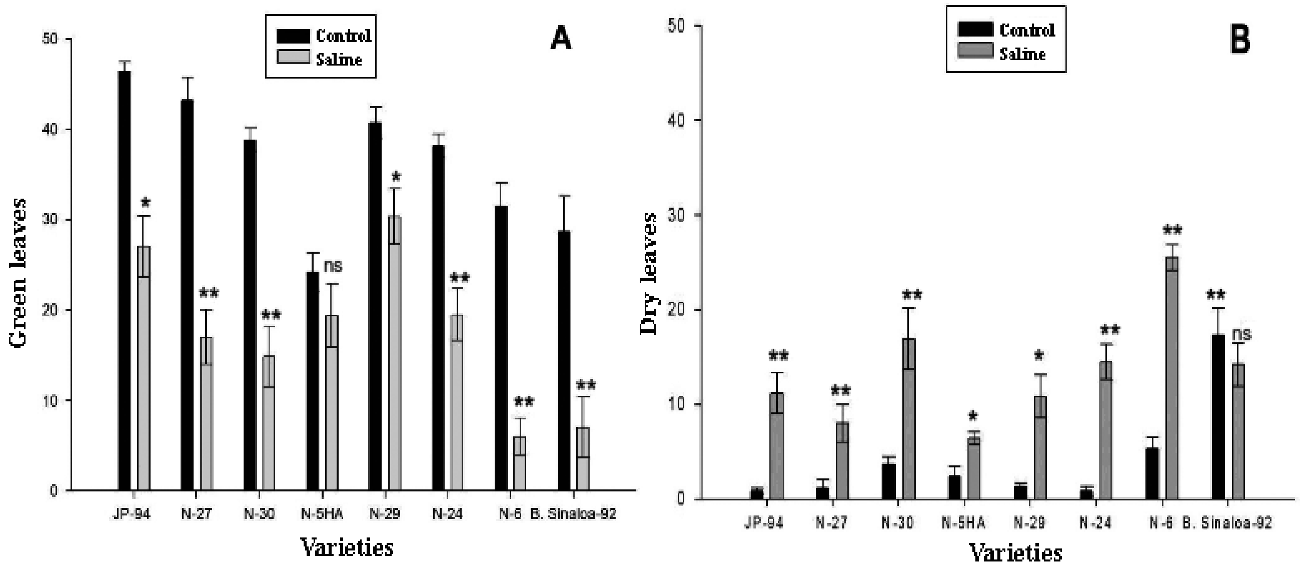
Therefore, the number of green leaves was affected by salinity, the effect being more marked in the cultivars Blanco Sinaloa-92, N-30 and N-6, as the time of exposure to salinity increased.

In this study, the results show that it is possible that Na^+ accumulates preferentially in the epidermal cells of the leaves, and that it is expelled to the outside of the leaf, thus reducing Na^+ toxicity.

With respect to the total dry mass of the plant (Figure 3), it is shown that cultivar N-29 showed a better response when exposed to saline conditions, it was also observed that it showed a greater amount of biomass in the salt treatments and it is the cultivar that reduces the least before these conditions, which may be due to a low toxicity of Na^+ in the organs of this cultivar.

The cultivars under study showed reductions, with respect to the biomass of the different organs; however, in only three cultivars (N-29, N-5HA and N-30) a higher content of dry mass was reached in the root, stem and leaves. On the other hand, the figure shows that the cultivar N-6 surpassed the rest of the cultivars, with respect to the total dry mass in saline conditions, such result can be given by the increase in the production of leaves of this cultivar, although it was seen negatively affected by salinity, observing a greater number of dry leaves than green, this may be one of the cultivars most sensitive to salt stress in this study.

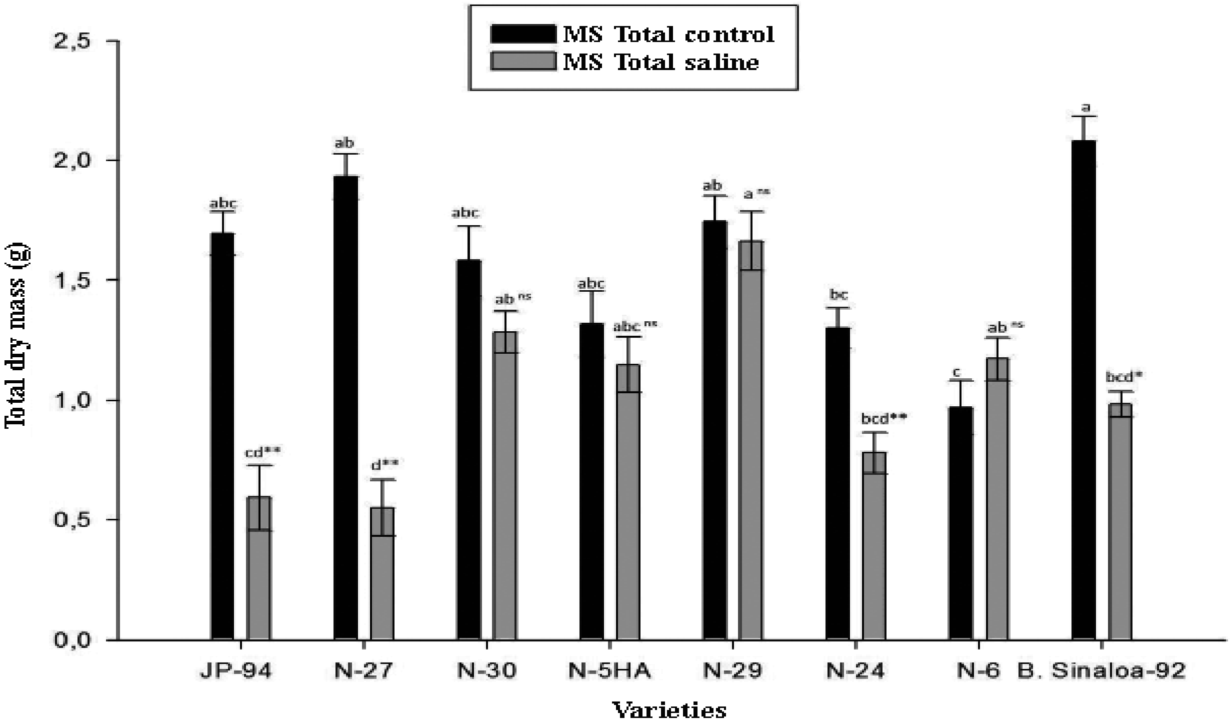
In this regard, other researchers evaluating tolerance to salinity of different cultivars of the Kabuli and Desi type, found a significant reduction of the biomass when they were exposed to salinity, this being greater in the control treatment (20).



A) Number of green leaves to 0 and 50 Mm of NaCl and B) Number of dry leaves to 0 and 50 Mm of NaCl

The vertical bars indicate the standard error of the means for p≤0.05

Figure 2. Number of green and dry leaves of chickpea cultivars exposed to two salinity conditions



The vertical bars indicate the standard error of the means for p≤0.05

Figure 3. Total dry mass of chickpea plants in two salinity conditions. Cultivars planted at 0 and 50 mM NaCl

On the other hand, other authors, evaluating saline stress until flowering and fructification in different chickpea lines, found a decrease in the biomass of the sprouts and the root (15).

In other works salinity levels similar to the present assay were evaluated in two chickpea cultivars of the Desi type, finding reductions in the dry mass of sprout and roots with respect to the control and only one cultivar was reduced to 6 % (26).

Plants can tolerate salinity by exclusion of sodium and chloride in the roots, accumulating ions in the lower leaves, so that the toxicity of ions is avoided in the growth of young leaves and in the development of reproductive tissues or tolerating ions in young and developing tissues (4,19).

Table 1 shows the concentrations of sodium, potassium, copper and manganese ions in the leaves of eight Cuban chickpea cultivars. It can be observed that the cultivars that turned out to be tolerant, taking into account the indicators of the biomass, sometimes accumulated less amount of ions in the different organs than the other sensitive genotypes.

In all the evaluated cultivars, the Na^+ concentration was increased, although they were very variable in the different organs, being the cultivars N-27 and N-5HA the ones that higher concentrations of sodium accumulated in the leaves of this culture in the conditions of imposed salinity.

On the other hand, cultivar N-29 was found to be one of the most tolerant cultivars when physiological variables were evaluated; When compared to the rest of the cultivars in both conditions, it was observed that it is one of the least accumulated ions in all its organs, although its accumulation in the leaves, are lower, to the amounts found in the stem and root, for saline treatment, this could be due to the fact that, when accumulating the greater amount of Na^+ in the other organs (stem and root), less of this toxic ion would enter the xylem and, as a consequence, less quantity would accumulate in the leaves , this may be a physiological mechanism of tolerance to salinity.

However, the cultivar N-5HA that also shows tolerance in the other indicators, the accumulation of ions is variable in the different organs; for example, this cultivar where more Na^+ accumulates is in the leaves, while in the root, when compared with other cultivars, is one of the least amount accumulates, we infer that these varieties may have salt excretory hairs and by the mechanism of exclusion takes these ions to the leaves and expelled to the outside by these hairs present in this body, since a high toxicity of this element reduces photosynthesis and enzymatic reactions.

Table 1. Concentration of sodium, potassium, copper and manganese ions in leaves of eight chickpea cultivars, grown in non-saline and saline conditions (50 Mm NaCl) 35 days after sowing

Variety	Na*10^{-2} (g kg^{-2})		K *10^{-2} (g kg^{-2})		Cu (mg kg^{-1})		Mn (mg kg^{-1})	
	Control	Salt	Control	Salt	Control	Salt	Control	Salt
Ion accumulation in sheets at 0 and 50 mM								
JP-94	17,8±5,1ab	99,9±11,2c**	9,0±0,5ab	36,4±5,6a**	1,0±0,03 c	0,5±0,02e**	9,4 ±0,6c	11,4±0,06ab**
N-27	0,8±5,6 ab	169,0±2,9ab**	10,8±0,3ab	35,8±1,4a**	1,9±0,14a	0,9±0,01b**	10,6±,07b	10,9±0,1 bc^{NS}
N-30	30,2±4,1a	102,3±11,2c**	9,4±0,2ab	10,5±0,1b**	1,4±0,01b	1,4±0,05a**	8,5±0,2d	9,0±0,8de**
N-5HA	5,2±1,1 b	139,9±39,4bc**	20,8±4,2ab	11,6±0,7b^{NS}	1,0±0,01c	0,7±0,04cd**	8,8±0,7cd	10,5±0,01 bc**
N-29	6,1±0,9b	39,0±14,3d^{NS}	7,9±1,2ab	7,5±0,02b^{NS}	0,8 ±0,02de	0,6±0,03d**	11,1±0,8b	8,8±0,4 e**
N-24	27,9±17,7ab	210,4±10,1a**	7,1±0 ,4b	7,6 ±0,5b^{NS}	1,5± 0,08 b	0,5±0,01e**	7,6±0,3e	7,0 ±0,6f**
N-6	13,5±13,1ab	160,6±43,6ab**	22,3±1,1a	9,9 ±1,8b**	0,8±0,05cd	0,7±0,02 cd^{NS}	14,0±0,1 a	10,0±0,2cd^{NS}
B. Sinaloa-92	13,2±3,4ab	128,4±3,2bc**	15,1±2,9ab	34,3±1,9a^{NS}	0,6± 0,01 e	0,7±0,009 c**	12,2±0,1b	14,0±0,07 a**

Mean with the same letters do not differ according to the Duncan HSD multiple comparison test

** y * = differences for 5% and 1% respectively by t-student; (±) = standard error of the mean

The other ions (K, Cu and Mn) were less accumulated by all the cultivars in the leaves, which is given by the own toxicity characteristics of Na^{+}.

These results coincide with those obtained by other researchers (19,27), where the Na^{+} concentrations in leaves of some genotypes were higher than those of K^{+}.

It has been shown that K^{+} is an element of great importance for this crop; however, it was demonstrated that their accumulation decreased substantially in cultivars N-29 and N-5HA, reaching the highest values in JP-94 and N-27. When the concentrations of this ion in the leaves were analyzed, it could be observed that potassium was in greater quantity in the saline treatment for all cultivars under study, these values being lower in the control treatment.

Although it was found in less quantities than Na^{+}, there was greater accumulation of this ion in the leaves, when we compared them with Cu and Mn, since it is an element that moves quickly from the old leaves to the newer parts.

The induced salinity decreased the content of these ions in the leaves; nevertheless, the Mn was in greater quantity than the Cu and this one accumulated more in the root than in the stems and the leaves, being significant its accumulation in the saline treatment that in the control. In addition, due to the limited mobility of Cu, it could be observed that this element was found in small quantities in the leaves, with greater availability of this element in the roots.

Table 2 shows the concentrations of these elements previously exposed but in the stem, also under two conditions of salinity.

When analyzing the concentrations of sodium in this organ for each cultivar, it could be observed that there was no significant difference in the non-saline treatment; however, when these plants were subjected to stress due to salinity, a great difference was observed between them, accumulating less quantity of this element in the N-29 and N-6 varieties. On the other hand, the cultivar N-5HA, which has been showing some tolerance, is one of the cultivars that accumulates more Na + in the stem when compared with the rest of the cultivars.

The entrance of K^{+} and Na^{+} in the cell is produced by the action of transporters and ion channels of the plasmalemma (28); however, there are very selective transporters for K^{+}, with a high affinity for this element (10-50 mM), but they can also transport Na^{+} with low affinity and be blocked by high concentrations of Na^{+} in medium (28).

This phenomenon was revealed in our investigation, it can be observed in this organ that potassium increases in almost all cultivars under saline conditions; however, in the cultivars N-5HA and N-30, it decreases with respect to the control and these same cultivars in the same condition of imposed salinity, increase the Na^{+} concentrations in the stem, so we agree with the results found (28).

Cu and Mn were found in similar proportions in the stems of the different varieties, these being quantitatively superior in the non-saline treatment.

With respect to Mn, it was observed that in cultivars N-29 and N-30 a greater quantity of this element accumulates, when the plants were subjected to stress due to salinity. In general, the Mn was more accumulated in the stem than the Cu, due to its translocation in this organ, being one of the main reserve tissues of this micronutrient, since when they reach the leaves they cannot be translocated . The low accumulation of Cu can also be given, to the little mobility that this element presents in the plant.

The root, as the main organ of absorption of water and ions, has great importance in the short and long term response to salt stress.

The anatomical and morphological characteristics of this organ can have a great influence on the ability to adapt to salinity (28). In Table 3, the found results of the accumulation of these ions in this organ are shown.

Based on the ion analysis of the root, it can be observed that the result obtained from the four elements in the different cultivars studied, showed different responses when comparing the other organs of the plant.

High levels of Na^+, a major ion in a saline environment, can induce the deficiency of the K^+ essential element, imposing an antagonistic effect on K^+, according to research carried out (29-31).

These results had the same tendency to those obtained by these authors (29-31), observing a high toxicity of sodium in this organ, resulting in a decrease in the absorption of potassium by the root; although in cultivar JP-94, in both conditions, showed less accumulation of K^+ than Na^+, this ion was in greater quantity in saline conditions than in the control.

Table 2. Concentration of sodium, potassium, copper and manganese ions in stems of eight chickpea cultivars, grown in non-saline and saline conditions (50 Mm NaCl) 35 days after sowing

Variety	Na*10-2 (g kg^{-2})		K *10-2 (g kg^{-2})		Cu (mg kg^{-1})		Mn (mg kg^{-1})	
	Control	Salt	Control	Salt	Control	Salt	Control	Salt
Ion accumulation in stems at 0 and 50 mM								
JP-94	14,4±6,2a	159,3±6,6ab**	9,5±1,8 c	49,1±1,3a**	1,0±0,05 ab	0,6 ±0,00c*	17,7±4,3a	7,1±0,08bNS
N-27	26,3±14,1a	171,6±1,1a**	7,5 ±0,2c	38,2±10,3a*	1,2±0,16 a	0,7±0,08bcNS	13,6±0,1ab	6,9 ±0,2b**
N-30	30,2±6,2a	91,3±0,9d**	8,8±0,2c	33,4±12,0a**	1,0 ±0,01ab	1,4±0,06a**	11,2±0,04bc	7,2± ,01b**
N-5HA	16,7±7,3a	169,9±24,6a*	16,1±4,8b	10,2±1,4bNS	1,0±0,01ab	0,6±0,01bc**	9,8±0,55bc	6,7± 0,2bNS
N-29	12,7±9,8a	108,6±10,9c**	8,8 ±0,5c	10,4 ±2,3bNS	0,7± 0,01c	0,6±0,02bcNS	9,5±0,9bc	10,1±0,1abNS
N-24	19,9±2,2a	164,7±0,8ab**	10,9±0,6bc	13,7±3,4b**	1,0±0,01 ab	0,9± 0,2b*	11,3±0,1bc	15,1± ,9a**
N-6	14,8±7,2a	148,1±0,1ab**	23,5±0,6 a	9,2 ±1,1bNS	0,9±0,02 b	0,7± 0,1bc*	7,2±0,04c	8,9±0,07b**
B. Sinaloa-92	10,5±0,8a	133,7±1,6bc**	12,9±0,2bc	32,6± 0,7aNS	0,5±0,01 c	0,5 ±,01bcNS	10,3±0,07bc	7,9±0,09bNS

Mean with the same letters do not differ according to the Duncan HSD multiple comparison test

** y * = differences for 5% and 1% respectively by t-student; (±) = standard error of the mean

Table 3. Concentration of sodium, potassium, copper and manganese ions in leaves of eight chickpea cultivars, grown in non-saline and saline conditions (50 Mm NaCl) 35 days after sowing

Variety	Na*10^{-2} (g kg^{-2})		K *10^{-2} (g kg^{-2})		Cu (mg kg^{-1})		Mn (mg kg^{-1})	
	Control	Salt	Control	Salt	Control	Salt	Control	Salt
Ion accumulation at root 0 and 50 mM								
JP-94	37,3±8,3c	187,2±21,0ab**	19,0±6,2b	27,2±4,6a^{NS}	1,0±0,04c	0,6±0,1d*	14,3± 4,4d	28,8±1,1 b*
N-27	20,8±3,6d	186,8±1,7ab**	91,3±0,8 c	10,3±,04cde**	2,3±0,1 b	0,8±0,03c**	25,8±0,8ab	26,5±1,1c^{NS}
N-30	5,2±9,5de	536,5±1,8cd**	20,8±0,6c	11,6±0,3cd**	1,0 ±0,1a	0,7± 0,08a**	8,8± 0,5cd	10,5±,07de^{NS}
N-5HA	35,6±0,6c	88,9±0,7d **	7,9±1,3c	17,8±0,09b**	0,7 ±0,2d	0,7± ,03cd^{NS}	22,3±0,1bc	9,9±0,07 f **
N-29	1,9± 0,04g	150,9±0,3bc**	9,7 ±0,09c	6,0±0,1e**	3,2 ±0,03a	0,7±0,04cd**	29,1± 0,3a	21,3±0,3e**
N-24	53,3± 0,1b	231,2±38,9a**	11,4 ±0,2c	9,8 ±0,06de^{NS}	3,0± 0,04a	0,5±0,07d*	16,6± 0,7d	33,3±1,3a**
N-6	67,9 ±6,4a	180,6±5,1abc**	7,6±0,6 c	7,0 ± 1,3de^{NS}	0,8 ±0,04cd	0,7 ±0,03cd^{NS}	26,4±0,1ab	23,8±0,4d**
B. Sinaloa-92	7,4 ±0,05ef	142,1±0,9bc*	29,6± 0,8a	15,6 ±0,2bc**	0,6 ±0,02d	1,0±0,01b**	26,6±0,2ab	26,2±0,4 c**

Mean with the same letters do not differ according to the Duncan HSD multiple comparison test

** y * = differences for 5% and 1% respectively by t-student; (±) = standard error of the mean

In recent studies in this culture against saline stress, low levels of Na $^+$ have been reported in some organs and reproductive tissues and it is inferred that they are unlikely to adversely affect reproductive processes (15,32,33).

The other copper and manganese ions showed a significant reduction with respect to sodium and potassium and these cultivars continue to show higher manganese absorption under stress conditions, because it is the area that most exports this element where required and is where it first it produces the affectation of its deficiency. The lowest accumulation values of these ions are observed in the variety N-29 and N-5HA, with respect to the control, which may be due to the high toxicity of sodium that is present in these cultivars.

These results agree with those obtained in another investigation (33), where the tolerance to salinity in the culture of the chickpea was determined.

CONCLUSIONS

- ♦ Salinity inhibited the development of the different cultivars under study, cultivars N-29, N-5HA of the Kabuli type and cultivar JP-94 of the Gulabi type were tolerant, while N-6, N-24 and Blanco Sinaloa -92 the susceptible and two moderately tolerant cultivars N-27 and N-30.
- ♦ Salinity led to significant variations in the variables evaluated, tolerant cultivars showed no differences in plant height, number of green leaves, biomass of different organs and little accumulation of ions in the root, stem and the leaves, when compared with the susceptible cultivars, where the cumulative effect of these changes leads to a better tolerance to stress.

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