Effect of Drought Stress on the Element Sodium Accumulation in Maize Root

Tayeb Saki Nejad [1], Leila Ghanbarizadeh [2]

[1.] Assistant professor Department of plant physiology Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
[2.] Soil Science Department, Marvdasht Branch, Islamic Azad University, Marvdasht, Iran
drtayebsaki@aol.com,
Tayeb saki1350@yahoo.com

Abstract: The conditions of soil and water are the most important factors effect on root growth and its activity. The roots are affected directly by water of the soil and it is affected indirectly by other physical factors such as ventilation, mechanical resistance, temperature and nutrition transmission from the soil to the root. Reviewing the process of sodium transmission and accumulation in the root at various depths of the soil showed following results: The effect of Irrigation period, growth phases and their interaction and also the effect of replications on the percentage of the root sodium accumulation at various depths of the soil have no significant effect. Duncan test presented 2-3 mean groups; on the other hand, by increasing the stress, the percentage of Potassium accumulation will increase. Maximum percentage of accumulation was observed in I3 treatment (0.64) and minimum percentage of Potassium was observed in the treatment without stress (0.12%). Reviewing the process of sodium accumulation at 3 sampling depths of A=0-20 cm, B=20-40, C=40-60 cm shows that maximum percentage of sodium was observed at C depth. By applying various levels of water stress, maximum percentage of accumulation of this element was observed at B. the accumulation of this element was in lower parts of the root and also a preventive status against sodium transmission was observed.

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1. Introduction

Different physical and chemical factors in rhizospher area such as plant characteristics are responsible for absorbing mineral by the root. believe that these factors are(44, 37 & 41):

1. Chemical composition of nutrition, their concentration in rhizospher solution of the soil, pH and ventilation.

2. The position of the elements in the soil, proportional to the distance of the plant root.

3. Element movement in relation with mass flow and diffusivity that implies on plant ability to create gradient of the material concentration and water potential in rhizospher

4. Growth, dissemination, form and physiological power of the root to move and absorb nutrition.

5. Secretion of organic material with low molecular mass of the root such as Amino Acid, gelatinous material with high molecular mass (mucilage), moulting and restoration of cells and tissues cause to move mineral directly or indirectly which provides necessary energy for microbial activity in rhizospher.

However, intensity of water and nutrition or single ions absorption is different, material enter the root in a solution shape and follow the same way with water flow. When the root is located in a solution which has a uniform concentration completely, the concentration in vascular tubes is higher than external solution. At the time of physical movement of ions (mass flow or diffusivity) to free space of the root (from Endoderm width to woody vascular), caution flow is more than anion flow. This is the result of abundance of negative charges on the surface of the cell wall. The number of the cautions and anions get into the root isn't usually equal. By getting same ions out of the root there would be a balance. The amount of nutrition with fix concentration which goes from the solution to the root depends on the position of plant salt and sweating rate (metabolic demand). The relationship between root Florence and ion absorption (such as iron absorption) is shown (22, 31). The ions within the root move actively or inactively. The active movement depends on metabolism and the energy which is provided by breathing and includes ion movement from an area that has low electrochemical potential to an area with high potential in 2 sides of the membrane and against the concentration gradient. Physical process of ion movement by active transmission might be the reason of against ion movement in the concentration gradient (inactive transmission). When external concentration of the material is low, (mechanism I: it shows the characteristics of active process) or it is high (mechanism II: it shows characteristics of inactive process) many minerals enter the root in free ion forms but there is exceptions such as urea or clats of the component. To explain the intensity of the element flow on the root surface, the word [power of the root absorption] [flux] is discussed and it is expressed as the ratio of element entrance per unit area(X).

X= water absorption speed (gcm² root surface s-1) / external concentration (gcm³)

Believe that the intensity of phosphorous and potassium flow to the root is a function of their concentration with the shape of saturation curve and they described it adjusted equation (7, 11).

In natural conditions, different parts of the root have different ability to absorb and transmit the material. Root age, volume and incomplete contact between the root and the soil, also effect on it. Irregular dissemination of the root in the soil and incomplete contact between the root and the soil, the interaction of causing microbe symbiotic, soil moisture, ventilation, temperature and pH effect on the element absorption of the root. Although, most of the ions absorbed by the root have positive effect on plant metabolism and its growth, accumulation of some elements such as aluminum, nitrite cause poisoning. Too much aluminum leads to stop growth and coraling of the root due to disorder in meitosis division in the root tip and decreases effective activity of the root and increases root toughness by pectin composition. Researcher reported that the amount of aluminum absorption by the root depends on root cation exchange capacity of the plant (r^2=0.991), therefore, this characteristic of the root might be used as a criterion to consolidate of aluminum. Absorption of material from the soil is a function of some factors which includes 3 groups, the root, rhizospher and soil mass. For example, in rhizospher where the soil changes are done completely by the root, the root causes to biological weather damage of phosphates, carbonates and silicates (2, 5, 7, and 25). Complex interference of these factors needs mathematical methods and much information. According to equation, (13, 14, 17) developed a model to measure the amount of material absorption from the soil. In this model, 10 characteristics of the soil and the plant are used which are: concentration of soil solution, differential coefficient of ion diffusivity in the soil, maximum flow intensity, constant, minimum concentration in which the plants are able to evacuate solution, root radius, the distance between the roots and intensity of water absorption, root growth constant and primary root length. Material absorption models by the root consist other characteristics such as root development speed, average root radius, average length and density of pull dims .Some authors believe that environment factors such as temperature, pH and the soil moisture are effective in these models. For instance Kasman says that the plant shows different models to sodium ion accumulation. We can point to a plan which needs Na+ that could be completely replaced by potassium and increases growth such as sugar beet or plant which couldn't be absorbed Na but couldn't be replaced of K+ completely, growth increasing by Na+ is observed such as cabbage, cotton, pea, linen, wheat and spinach. There are plants which absorb little Na+ such as barley, rice, oat, tomato, ryegrass, potato, this little Na+ could be replaced of potassium. Other models includes the plants such as corn, rye, soya, crop bean and timothy in which replacement of K+ by Na+ isn't observed and growth increasing by sodium is meaningless(1, 52).

2. Material and Methods

This experiment was performed in factorial and split plot method with 4 replications. The main and secondary treatment are defined and executed as follows:

1. Main treatment consists various irrigation which are defined and planned as follows:

I0: complete irrigation at FC point

I1: 75% of S0 treatment irrigation, moderate stress

I2: 50% of S0 treatment irrigation, severe stress

I3: 25% of S0 treatment irrigation, very severe stress (at PWP point)

To apply the treatment of water stress, weight method was used to determine the percentage of soil moisture once in 3 days. The percentage of weighted moisture and volumetric percentage of the soil moisture was measured by this method due to constant volume of sampling cylinder bore (V), the percentage of weighted moisture and volumetric percentage of soil moisture were measured by following formulas:

Mass percentage of the moisture:

$$\%\theta_M = \frac{W_1 - W_2}{W_2} * 100$$

Volumetric percentage of the moisture:

$$\%\theta_V = \frac{W_1 - W_2}{V} * 100$$

Then, the amount of water entering to each plot is calculated by using Parshal Flume

$$V = \frac{\theta_V .A.D_S}{E} = \frac{\theta_m .P_a A.D_S}{E} = \frac{(Fc - pwp)p_a .A.D_S}{E}$$

2. Secondary treatment

It includes various plant growth phases which are defined and planned as follows:

S0: vegetative phase: from the plant establishment to stem appearance stage.

S1: reproductive phase: from stem appearance to browning of silk and pollination.

S2: seed filling phase

3. Results

Reviewing the process of sodium transmission and accumulation in the root at various depths of the soil showed following results:

1. The effect of Irrigation period, growth phases and their interaction and also the effect of replications on the percentage of the root sodium accumulation at various depths of the soil have no significant effect. (Table 1).

2. Duncan test presented 2-3 mean groups, on the other hand, by increasing the stress, the percentage of Potassium accumulation will increase. Maximum percentage of accumulation was observed in I3 treatment (0.64) and minimum percentage of Potassium was observed in the treatment without stress. (0.12%) (Table 2)

3. Reviewing the process of sodium accumulation at 3 sampling depths of A=0-20 cm, B=20-40, C=40-60 cm shows that maximum percentage of sodium was observed at C depth. By applying various levels of water stress, maximum percentage of accumulation of this element was observed at B. the accumulation of this element was in lower parts of the root and also a preventive status against sodium transmission was observed. (Fig 1).

Table 1. The results of variance analysis of the percentage of root sodium accumulation at various soil depths (cm)

S.O.V	df	A =0 – 20	B =20 – 40	C =40 – 60
Replication	3	0/0011 $^{n.s}$	0/0011 $^{n.s}$	0/0011 $^{n.s}$
Irrigation period	3	0/0071 $^{n.s}$	0/0081 $^{n.s}$	0/0061 $^{n.s}$
E_a	9	-	-	-
Main plot	15	-	-	-
Growth phase	2	0/0021 $^{n.s}$	0/0031 $^{n.s}$	0/0012 $^{n.s}$
Interaction effect	6	0/0001 $^{n.s}$	0/0001 $^{n.s}$	0/0001 $^{n.s}$
E_b	24	-	-	-
Sub plot	32	-	-	0_
Total	47	-	-	-
CV%	-	17	18	15

The process of Na+ movement accumulation occurred at C and B depth, especially at C height. Their transmission to A depth was negligible. Most of absorbed sodium in the root, accumulated at C depth. This process increased by applying more severe water stress. The slope of regression equation (y= *0.09x-.005*) showed this increasing process. It is because of not sodium transmitting to upper parts by the plant. In some plants such as corn, sodium transmission to the shoots is impaired by endodermis layers to prevent harmful effect of it. Although this species are sensitive to sodium, on the other hand, some plants such as sugar beet resist against this element by transmitting sodium to different parts of the plant that causes to dilute the salt in a special tissue.

Table 2: comparison of root sodium percentage means in Duncan test at the level of 1% at various soil depths (cm)

Treatment	A =0 – 20	B =20 – 40	C 40 – 60 =
I_0	c0/14	c0/12	B0/11
I_1	c0/15	b0/16	B0/11
I_2	b0/43	a0/41	A0/32
I_3	a0/51	a0/43	A0/34
S_1	c0/03	c0/01	c0/02
S_2	a0/63	a0/52	a0/71
S_3	b0/09	b0/06	b0/08
I_0 S_1	e0/022	c0/01	e0/021
I_0 S_2	c0/091	b0/062	cd0/078
I_0 S_3	d0/062	b0/06	d0/072
I_1 S_1	e0/027	c0/017	e0/03
I_1 S_2	ab0/11	ab0/083	bc0/095
I_1 S_3	a0/116	a0/092	a0/13
I_2 S_1	e0/032	c0/022	e0/038
I_2 S_2	bc0/092	ab0/091	B0/1
I_2 S_3	bc0/093	a0/093	ab0/11
I_3 S_1	e0/033	c0/02	e0/029
I_3 S_2	ab0/112	a0/111	a0/131
I_3 S_3	ab0/11	a0/101	a0/127

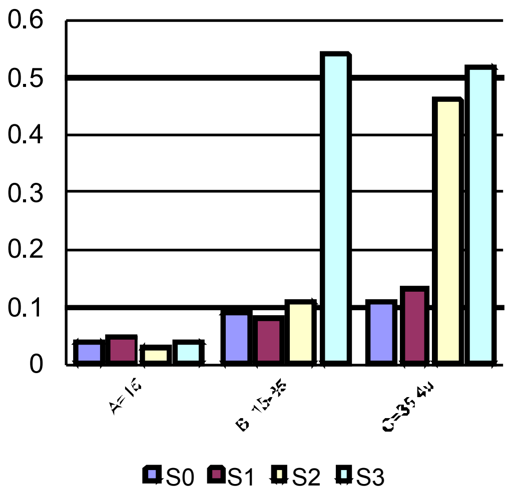

Figure 1: Effect of different levels of water stress (s) on the *percentage of sodium* accumulation in roots at different depths (cm from the floor)

4. Discussions

Sodium accumulation and transmission process showed that maximum percentage of sodium accumulation is in the root tip and transmission upward is so limited by applying water stress. David has discussed about prevention of endoderm layers from sodium permeation to the shoot in the corn.

Acknowledgements:
Department of plant physiology Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

Corresponding Author:
Dr. Tayeb saki Nejad
Assistant professor Department of plant physiology Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
drtayebsaki@aol.com,
Tayeb saki1350@yahoo.com

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