

Original Research Article

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Potential Absorption of Calcium in Sunflower (*Helianthus annuus* L.) and its effect on pH and electrical conductivity

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ABSTRACT

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Hard water, sunflower, nutritional deficiencies, necrosis

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In order to know the dynamics of calcium absorption in sunflower seedlings, an experiment was established under laboratory conditions, at the Universidad Tecnológica de Tehuacán, to evaluate five levels of $\text{Ca}(\text{CO}_3)_2$ in the solution. The variables were: absorbed calcium, pH, electrical conductivity, root length and volume, which were evaluated under a completely randomized design and four replicates (5×4) = 20 experimental units. The results indicate that sunflower can absorb Ca^{++} , in solutions up to 160 mg L^{-1} and support, pH levels of 10.5 and 6.5 dSm^{-1} . The length as well as the root volume decreased as the calcium concentration increased. From this research it can be concluded, that sunflower can grow and absorb calcium, at concentrations of $160 \text{ mg L}^{-1} \text{ Ca}^{++}$ in the solution.

Introduction

Sunflower (*Helianthus annuus* L.), is a plant that is taxonomically classified within asteraceae (Redonda and Villaseñor, 2011, López, 1990). This has its center of origin according to Vavilov, in the north of Mexico and southeast of the United States of America (Concepción, 2005). This crop plant, has been the object of many uses among which we can cite: oleaginous, ornamental, and food for livestock (Ávila, 2009). Currently as a bioremediation plant, by the ability to absorb

heavy metals like Pb (Chico *et al.*, 2012). In this respect Escalante *et al.*, (2017), mention that the sunflower is a plant, which can grow on soils that have been affected by hard water, besides having the ability to decrease, the pH as well as the electrical conductivity of the soil. With respect to calcium, this is considered as a macroelement for plant nutrition, because it forms an important part of the cell wall of vegetables, as it intervenes in the pectic structure of plant cells (Galviz *et*

al., 2003), Even when it is missing, in some vegetables like the tomato, can cause damage to the apical part of the fruit of this species, known as apical necrosis (Martínez *et al.*, 2009). Salisbury and Ross (1994), mention that this necrosis, is due to nutritional deficiencies of Ca^{++} , since this is required in greater quantity to form a medium sheet in the fragmo blast, between the daughter cells, coming from the process of mitosis and, thus, to satisfy the needs of the membranes in formation. The pH and electrical conductivity, are soil chemical parameters of great importance, because the productivity of the soil, depends to a great extent on these, since the absorption of water and nutrients are limited by these. For this reason the objective of the present investigation was: determine the effect of sunflower on calcium absorption, pH and electrical conductivity, when it is subjected to different levels of Ca^{++} in solution. The hypothesis was: the sunflower will lower the pH and electrical conductivity of the solution due to the ability to absorb Ca^{++} from the solution.

Materials and Methods

The present investigation was carried out under laboratory conditions, in the facilities of Tehuacan Technological University, located at 18° 24'51" north latitude, 97° 20'00" longitude west and 1409 meters of altitude. The germplasm, consisted of seedlings obtained from achenes of sunflower cv. Victory, which were planted on July 29, 2016, in 200 well trays using peat moss as a substrate. When the seedlings had a height of ten centimeters, were transplanted into glass containers of 325 ml capacity, placing one seedling per container. The experimental design used was completely randomized under the mathematical model, $Y_{ij} = \mu + T_i + \varepsilon_{ij}$, where: Y_{ij} , is the response variable of the i -th $\text{Ca}(\text{CO}_3)_2$ concentration in the j -th repetition; μ , is the true overall mean; T_i , is the

effect of the i -th concentration of $\text{Ca}(\text{CO}_3)_2$ and ε_{ij} , is the experimental error of the i -th concentration of $\text{Ca}(\text{CO}_3)_2$ in the j -th repetition (Cochran and Cox, 1990; Steel and Torrie, 1985). The treatments consisted of five concentrations of $\text{Ca}(\text{CO}_3)_2$, 0; 40; 80; 120 and 160 mg L^{-1} , and four replicates (5×4) = 20 experimental units, evaluated at 8, 16, and 23 days after transplantation. The experimental unit, was made up of a container with solution and a sunflower seedling. The response variables were: absorbed calcium, which was determined using a LAQUA B-751 ionometer, placing the extract of the petiole of a leaf of each sunflower seedling, corresponding to each treatment and expressing the result in mg L^{-1} ; pH and electrical conductivity, determined using a Hanna potentiometer, model HI991300, for each solution. Root length, Measuring from the beginning of the hypocotyl, to the radical meristem, with a ruler and expressing the result in centimeters. The root volume, was calculated by the principle of Archimedes, Placing the root of each treatment in a 100 ml test piece, in a known volume of water 50 ml, And the displaced water volume, is the root volume expressed in cm^3 . When the response variables were significant, Tukey's multiple comparison test was applied, at a significance level of 5% of error probability.

Results and Discussion

Calcium absorbed

The analysis of variance for absorbed calcium, showed that there were highly significant differences between treatments, at 16 and 23 days after transplantation (dat). The coefficient of variation, various in the range of 2.13 to 3.62%, showing that the data were very reliable (Table 1). Regarding the absorption of calcium, this presented an upward behavior, at 8, 16 and 23 dat. Thus at 16 dat, the maximum calcium absorption

occurred in the treatment T₁₆₀ with 59.92 mg L⁻¹ of Ca⁺⁺, while the lowest was for treatments T₀ and T₄₀ with 40.75 and 45.42 mg L⁻¹, this same trend, remained at 23 dat. This effect of calcium absorption has been studied by Goycovik and Saavedra (2009), who mention that calcium affects crops negatively, being the germination process that is most affected, due to the high osmotic pressures caused by calcium, thus preventing the imbibition of seeds.

pH

The pH dynamics at 8, 16 and 23 dat, showed a decreasing growth in all treatments at the three mentioned dates. The maximum pH was presented in treatments T₁₂₀ and T₁₆₀, being these, where the sunflower seedlings were able to cushion, the pH to maintain it almost constant between the 8 and 16 dat. This behavior was due to water consumption, which caused that as the days went by, the calcium concentration was higher, which is why the pH presented an increase in all treatments.

Electric conductivity

Figure 2 shows the dynamics of the electrical conductivity. It shows that the electrical conductivity, had a behavior similar to pH, where the treatments T₁₂₀ and T₁₆₀, presented the highest levels of this parameter. This response has been proven by Sánchez *et al.*, (2014) and Castellanos and Borbón (2009), who mention that the progressive accumulation of salts, is due to the absorption of water and nutrients by cucumber cultivation, in addition to the evapotranspiration phenomenon.

Root length and volume

The analysis of variance for root length and volume is presented in Table 2. It can be seen that there were highly significant differences between treatments, for both variables. Regarding the coefficient of variability, this ranged from 6.74 to 13.08%, which shows that the data were very reliable.

Table.1 Analysis of variance and Tukey's multiple comparison test, For calcium absorbed by sunflower seedlings (*Helianthus annuus* L.), cv. Victory. Universidad Tecnológica de Tehuacán. 2016

Treatment	dat		
	8	16	23
mg L ⁻¹	mg L ⁻¹		
T ₀	32.57 a	40.75 e	41.10 e
T ₄₀	33.35 a	45.42 d	45.05 d
T ₈₀	33.65 a	50.25 c	50.55 c
T ₁₂₀	33.42 a	55.25 b	56.02 b
T ₁₆₀	33.42 a	59.92 a	61.35 a
SDH	2.62	2.95	2.37
ANOVA	n.s	**	**
CV %	3.62	2.68	2.13

Medias within columns with the same literal, are statistically the same according to Tukey at P <0.05; dat, Days after transplantation; SDH, significant difference honest; CV, coefficient of variation; **, *, n.s, significant at 0.01, 0.05 and not significant.

Table.2 Analysis of variance and multiple comparison test, for two response variables, subjected to five levels of $\text{Ca}(\text{CO}_3)_2$, in the solution in sunflower seedlings (*Helianthus annuus* L.). Universidad Tecnológica de Tehuacan. 2016

Treatment mg L^{-1}	RL cm	RV cm^3
T₀	9.33 a	0.76 a [¶]
T₄₀	6.66 b	0.56 b
T₈₀	6.00 bc	0.43 bc
T₁₂₀	5.36 cd	0.33 cd
T₁₆₀	4.60 d	0.26 d
SDH	1.15	0.16
ANOVA	**	**
CV%	6.74	13.08

Medias within columns with the same literal, are statistically the same according to Tukey at $P < 0.05$; dat, Days after transplantation; SDH, significant difference honest; CV, coefficient of variation; RL, Root length; RV, Root volume
**, *, n.s, significant at 0.01, 0.05 and not significant.

Fig.1 Dynamics of pH of the solution at five concentrations of $\text{Ca}(\text{CO}_3)_2$, with sunflower seedling. Universidad Tecnológica de Tehuacan. 2016

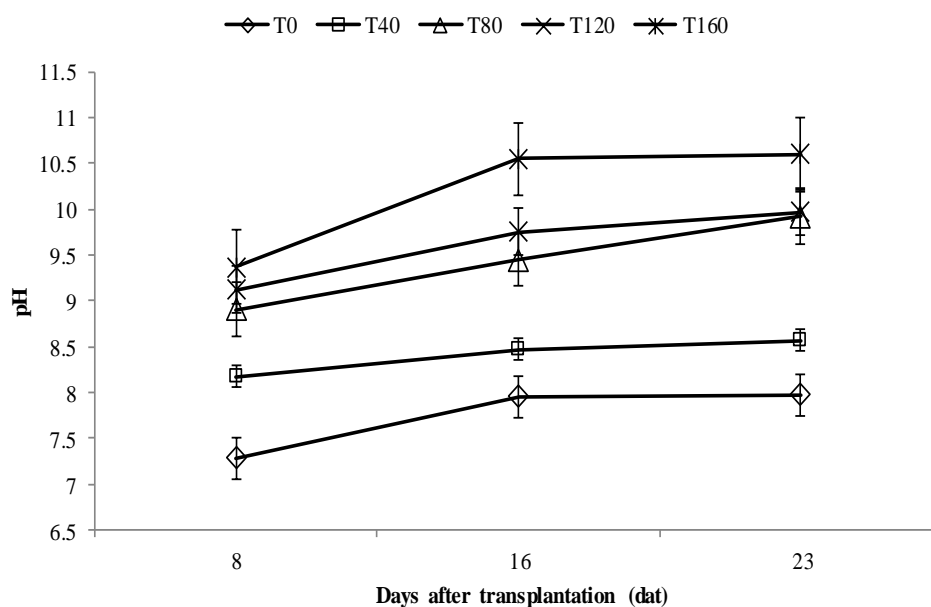
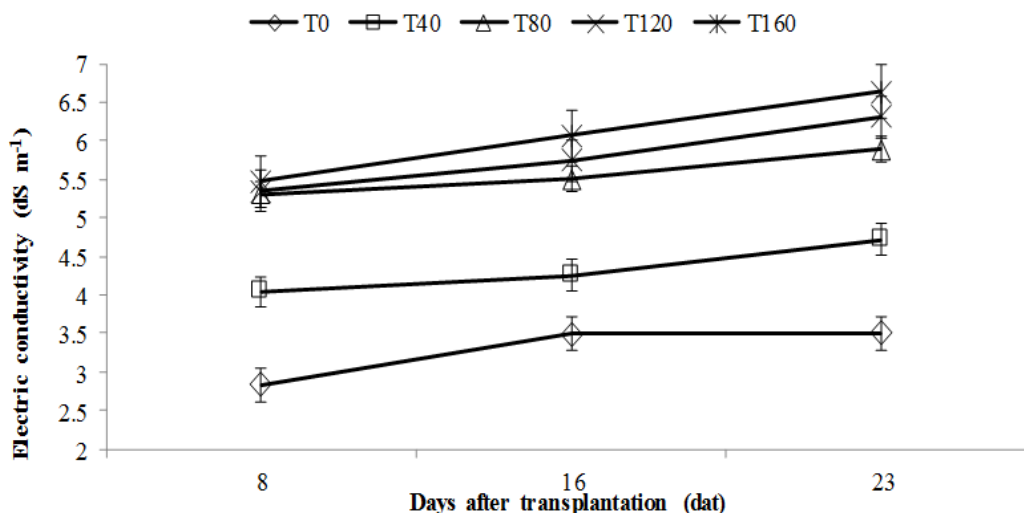


Fig.2 Dynamics of the electrical conductivity of the solution,
With sunflower seedlings (*Helianthus annuus* L.) under five levels of Ca (CO₃)₂.
Universidad Tecnológica de Tehuacan. 2016



Regarding the multiple comparison test, the highest root length corresponded to the control treatment, with 9.33 cm overtaking the other treatments.

This variable tended to decrease as the concentration of Ca (CO₃)₂ increased, thus the shortest length was in treatments T₁₂₀ and T₁₆₀ with 5.36 and 4.60 cm respectively.

With respect to root volume, it can be asserted that it had a similar behavior as the length, because the highest root volume corresponded to the control with 0.76 cm³, while the lowest occurred in T₁₂₀ and T₁₆₀ with 0.33 and 0.26 cm³. The root length reported in this research, Agrees with the data of Moreno *et al.*, (2011), who mention that the cultivation of cucumber in high densities of population, under seedling conditions, presented a root length of 10.0 cm, while the root volume differs, since they report a volume of 6.9 cm³, difference that was due to the type of substrate that they used.

The following conclusions were drawn from the present investigation:

Sunflower is a plant that absorbs up to 160 mg L⁻¹ of calcium, from the solution.

The pH and electrical conductivity of the solution were increased by the effect of evapotranspiration.

Sunflower is a species that can grow under high calcium conditions where other species would not thrive.

Due to the calcium absorption capacity, sunflower could be used in the future, as a plant to bioremediate soils, affected by high concentrations of calcium.

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