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Article

Dióxido de silicio como estimulante del índice de calidad de plantas de chile piquín (*Capsicum annuum* L. var. *glabriusculum*) producidas en vivero

Silicon dioxide as a stimulant of the quality index of nursery-grown pequin pepper (*Capsicum annuum* L. var. *glabriusculum*) plants

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Resumen:

Desde el siglo pasado el dióxido de silicio ha tomado notoriedad, no solo por su rol en los componentes electrónicos, sino también por sus efectos benéficos en algunos cultivos como el arroz o la fresa. El objetivo del presente estudio fue conocer los impactos del dióxido de silicio como fertilizante sobre la calidad de planta del chile piquín. El trabajo se desarrolló en el vivero de la Facultad de Ciencias Forestales de la Universidad Autónoma de Nuevo León, durante enero-mayo de 2016. Se aplicaron tres tratamientos más el testigo: 1) testigo, 2) dióxido de silicio, 3) lombricomposta, y 4) una mezcla de lombricomposta y dióxido de silicio. Se monitoreó el crecimiento de la planta en altura cada cinco días, después de la fertilización se utilizó el Índice de Calidad de *Dickson* para evaluar la calidad de la planta al finalizar el experimento. Los resultados indicaron que la lombricomposta y el dióxido de silicio tuvieron un mayor incremento medio de altura de planta, a 14 cm y 12.8 cm, respectivamente; seguido del testigo (11.25 cm), y por último, la mezcla de dióxido de silicio con la lombricomposta (11 cm). El Índice de Calidad de *Dickson* fue más alto con el dióxido de silicio y la lombricomposta; la mezcla de ambos tuvo un promedio más bajo con alta variación, finalmente, en las plantas testigo se estimó el menor índice.

Palabras clave: Calidad de planta, crecimiento de planta, dióxido de silicio, estimulante vegetal, Índice de *Dickson*, lombricomposta.

Abstract:

Since the last century silicon dioxide has become notorious not only for its role in electronic components but also for its beneficial effects on some crops such as rice or strawberry. The work was carried out in the *Facultad de Ciencias Forestales* of the *Universidad Autónoma de Nuevo León* (UANL) in the nursery area. It was carried out in the January-May season of 2016. Four replications of 10 plants each were carried out for each of three fertilizers —silicon dioxide, earth worm compost, and a mixture of earth worm compost and silicon dioxide— and a control. Two results of the experiment were obtained: firstly, a temporary growth was registered throughout the experiment for each treatment, the earthworm compost being the one that obtained the greatest average increase in the height of the plant, to 14 cm, followed by the silicon dioxide, with an average increase to 12.28 cm; the control, with 11.25 cm, and, finally, the mixture of silicon dioxide and earth worm compost, with 11 cm. The second result was the plant quality, measured with Dickson's quality index, for which the silicon dioxide obtained the highest value, followed by the earthworm compost; the fertilizer mixture yielded a low average but exhibited a high variability, and the lowest value was for the control.

Key words: Plant quality, plant growth, silicon dioxide, plant stimulant, Dickson Index, earthworm compost.

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Introduction

Mexico occupies the second place in the culture of green chili peppers, with 8 % of the worldwide production (FAOSTAT, 2009). Chili peppers are one of the main crops produced in the country, due to their high participation in the value of the regional agricultural production, as well as to the income and jobs that they generate in the areas where they are produced. Today, they are the leading horticultural product in Mexico, with a cultivated surface area of almost 150 thousand hectares, a production above one million and a half tons per year, and an average value of 1 387 823 854 MXN in the period between 1993 and 2002 (Sagarpa, 2007).

In addition to its cultural value in pre-Hispanic Mexico, the genus *Capsicum* plays a socioeconomic role in the north of the country, where 15 % of the rural communities are devoted to harvesting pequin peppers, an activity that generates 60 g% of their income (Medina *et al.*, 2007).

Pequin pepper is a wild plant that grows in different ecosystems of northeastern Mexico, mainly in the Tamaulipan shrubs, and it is a non-timber forest resource with a great ecological and socioeconomic importance.

The population displays a great preference for pequin pepper, compared to *serrano* or *Jalapeño*. In northern Mexico, over 50 % consumers were willing to pay between $51 and $500 MXN for a kilo of fresh pequin peppers, although they cost 40 to 100 times more than *Jalapeño* and *serrano* peppers. Their great acceptance indicates their high potential in the market (Villalón-Mendoza *et al.*, 2014).

Silicon is better known for its use in electronic components; however, it has been proven that, although it is not an essential element for the plants, it has qualities that contribute to the development and yield of certain species, as pointed out by Corzo (2013), who fertilized oil palm trees with silicon and obtained an increase in the number of green leaves, as well as a greater growth throughout the year, compared to unfertilized palm trees.

The objective of the present research was to learn the effects of silicon dioxide on the quality of nursery-grown pequin pepper plants.

Materials and Methods

The experiment was carried out from January to May, 2017, at the facilities of the forest nursery of the *Facultad de Ciencias Forestales* (School of Forest Sciences) of the *Universidad Autónoma de Nuevo León* (UANL), located at the coordinates 24°47.917´ N and 99°32.508´ W, at a distance of approximately 8 km south of the central area of *Linares* municipality, *Nuevo León*, Mexico.

Three fertilization treatments and a control were assessed, with four repetitions of 100 plants each, adding up to a total of 400 seedlings per treatment (Villalón-Mendoza *et al.*, 2015). The variables height and number of leaves were recorded.

Capsicum annuum L. var. *glabriusculum* seedlings were utilized; they were germinated at the forest nursery, 30 days before the experiment, in a seedbed with 5 000 ppm of giberellic acid in peat moss (70 % peat moss + 20 % perlite + 10 % river sand), in plastic germination trays with 128 cavities, each of which measured 2 cm × 2 cm × 5 cm. The plants were subsequently transplanted to 350 cm^3 bags. The substrate utilized was a mixture of 50 % soil, 30 % peat moss, and 20 % perlite.

Data of height, number of leaves, dry weight and fresh weight of the plants were recorded at the initial stage in order to compare them with the same data at the end of the experiment. After applying the fertilization treatments, the final data of the plant were recorded in order to learn the effects of the treatments on the quality of the plants.

The four treatments were the following: 1) control plants; 2) fertilization with silicon dioxide, at the rate of 20 g L^{-1} of water; 3) earthworm compost (earth worm compost leach liquor), in a proportion of 20 cm^3 L^{-1} of water, and 4) a mixture of silicon dioxide (20 g L^{-1} of water) and earth worm compost (20 cm^3L^{-1} of water). Earth worm compost works well as a fertilizer for pequin pepper (Malacara *et al.*, 2016).

Fertilization was foliar and was carried out immediately after the transplant. Subsequently, the plants were fertilized every 10 days, until May 14. The concentrations of Agronil® silicon dioxide were 19 grams for every liter of water, applied manually with sprinklers. Measurements were made, and the data recorded every 15 days and captured in a database for later analysis.

The database was built with the data of 20 randomly selected plants out of the 400 subjected to each treatment.

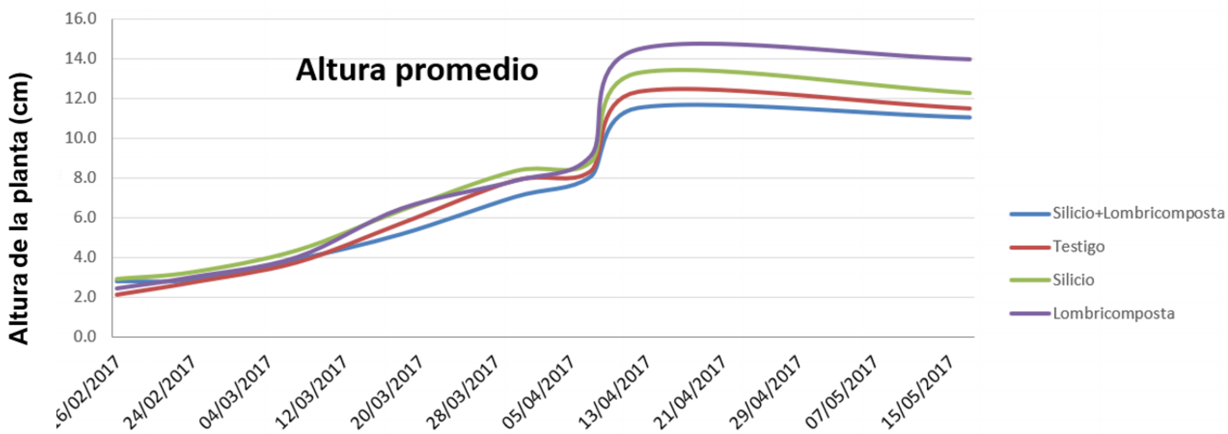
They were then analyzed using Dickson's Quality Index:

$$DQI = \frac{Total\ dry\ weight\ of\ the\ plant\ (g)}{\frac{Height\ (cm)}{Diameter\ at\ root\ neck\ (mm)} + \frac{Dry\ aboveground\ weight\ (g)}{Dry\ root\ weight\ (g)}}$$

Results and Discussion

Figure 1 shows the differences in height between treatments. Those plants in which earthworm compost were used had a greater stimulus for growth, with a mean of 14 cm; next was the treatment with silicon dioxide, with an average of 12.28 cm. The controls exhibited an average height of 11.25 cm, and the use of silicon dioxide together with earth worm compost resulted in an average height of 11 cm, the lowest value. These results agree with those obtained for the fertilization of wild pequin pepper seedlings by Malacara *et al.* (2016), according to whom earth worm compost was one of the best treatments, as was the slow-release mineral fertilizer.

In this research, the height of the plant registered an exponential increase in growth and in the number of leaves during April; this is mainly due to the change in the climate conditions of the region in the spring, as well as to the rainfalls that took place during that period (Figure 1). In a test of 10 pequin pepper harvests from northeastern Mexico, Medina *et al.* (2003) observed the same behavior with their treatments.



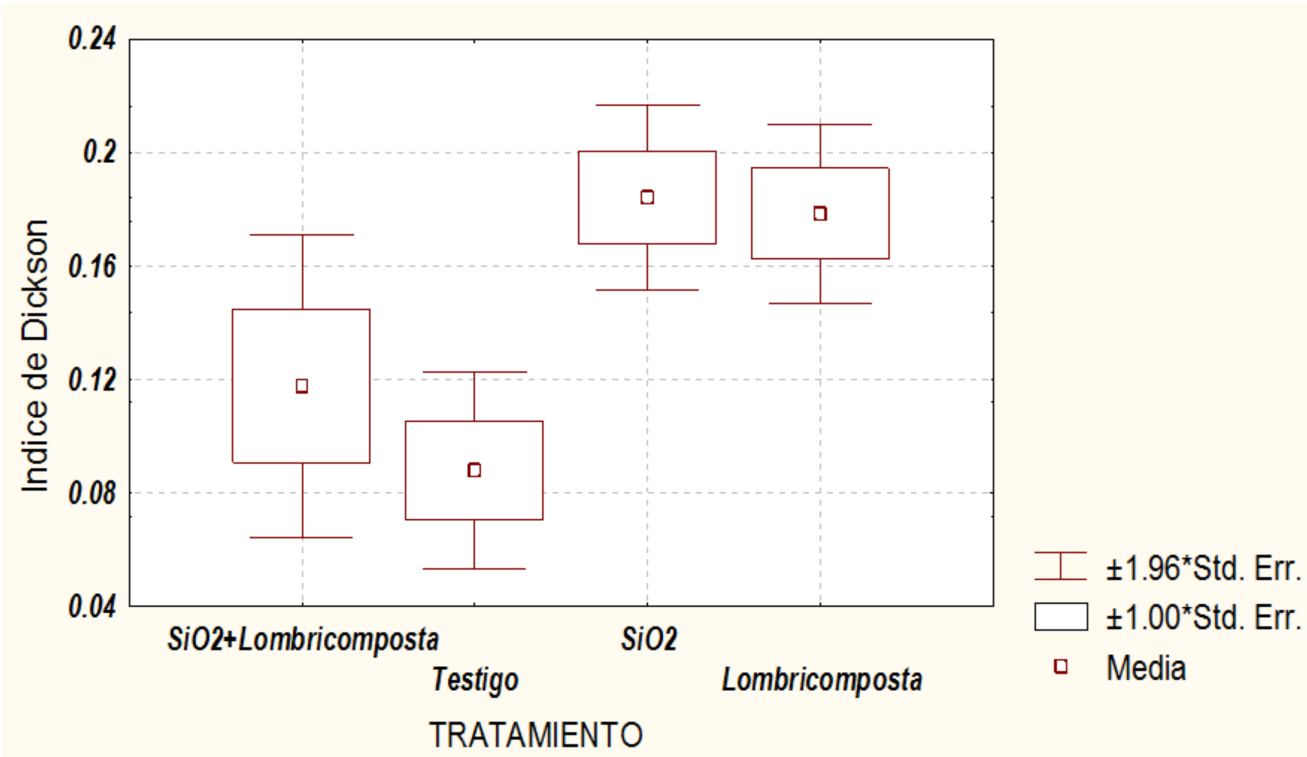
Altura de la planta = Height of the plant (cm); *Altura promedio* = Average height; *Silicio +lombircomposta* = Silicon dioxide + earthworm compost; *Testigo* = Control; *Silicio* = Silicon dioxide; *Lombricomposta* = earthworm compost

Figure 1. Height of the pequin pepper plant under four different fertilization treatments (February 16 to May 15, 2017).

Plant Quality Index

Figure 2 shows the results of the plant quality index, which evidence that the treatments with the best performance were silicon dioxide and earth worm compost. Unlike the control, the mixture of silicon dioxide and earth worm compost attained a mean of 0.12. However, the data distribution interval was very broad, as in the case of the control. Therefore, continuity should be given to research assessing the behavior of the plant after transplantation to the field.

According to Bañuelos *et al.* (2008) and Dickson *et al.* (1960), Dickson's index is one of the main variables in the results of tests of the management of the production of nursery-grown plants. Therefore, it is considered adequate to use this index to measure the effect of silicon dioxide as a stimulant in order to assess the quality of the production of nursery-grown wild chili plants, which equaled the quality of plants fertilized with earth worm compost and surpassed that of the control treatment.



Índice de Dickson = Dickson's index; *Tratamiento* = Treatment; *Media* = Mean; *Testigo* = Control; *Lombricomposta* = Earth worm compost

Figure 2. Dickson's index for the four treatments.

There are still gaps in the research on the use of silicon dioxide as a fertilizer, as neither the maximum assimilation points nor the toxicity of silicon have been determined. However, the results in the present research were similar to those cited in the literature (Feng y Yamaji, 2006, FAO, 2009, Corzo, 2013), though they are not easily comparable, because the effects of fertilization with silicon dioxide on plant quality in most of the research carried out in a variety of crops are not usually taken into account; the yield of the plant is the only recorded datum. Feng and Yamaji (2006) document larger increases in the production of rice plants to be transplanted, when similar doses of silicon dioxide are applied. This coincides with the results of the present study, in which a larger initial increase was observed in the height of the pequin pepper plants —a crucial factor that determines the need to transplant them more promptly in order to reduce the risk of attacks by fungi, such as damping off. Furthermore, their results agree with those of Corzo (2013) for oil palm trees fertilized with silicon dioxide, which attained larger heights during the year.

Table 1 summarizes the statistics for all the measured variables. Difference were obtained only in the plant quality index (Dickson's quality index, p=0.03053); on the other hand, the root length, final plant height, diameter at neck base, dry root weight, aboveground weight, leaf area, green root weight and green aboveground weight were equal for all treatments.

Table 1. Variance analysis for the different variables assessed in the present study with a p value ≤0.05.

Variable	SC effect	Gl effect	CM effect	SC Error	Gl Error	CM Error	F cal	p
Dickson's index	0.024083	3	0.008028	0.023048	12	0.001921	4.179546	0.03053*
Root length	82.41533	3	27.47178	633.3347	12	52.77789	0.520517	0.676170
Height of the plant	59.17221	3	19.72407	478.8422	12	39.90351	0.494294	0.692945
Diameter at neck base	0.137500	3	0.045833	2.300000	12	0.191667	0.239130	0.867382
Dry root weight	0.133033	3	0.044344	0.465142	12	0.038762	1.144024	0.370914
Dry aboveground weight	0.201503	3	0.067168	0.468297	12	0.039025	1.721160	0.215687
Leaf area	5.466325	3	1.822108	31.12768	12	2.593973	0.702439	0.568564
Green root weight	2.705974	3	0.901991	3.351620	12	0.279302	3.229452	0.060885*
Green aboveground weight	0.766678	3	0.255559	2.016522	12	0.168043	1.520794	0.259509

*Observed statistical difference.

It should be noted that the maximum and minimum absorption values of silicon by pequin pepper plants are unknown, and the optimal dose of this element still remains to be determined (Feng and Yamaji, 2006).

Conclusion

Silicon dioxide has a positive effect on the growth and quality of pequin pepper (*Capsicum annuum* L. var. *glabriusculum*) plants which results in a higher plant quality and greater growth; therefore, it is a viable alternative for the fertilization of pequin pepper plants.

Conflict of interests

The authors manifest that we have an employment and a student's relationship with the School of Forest Sciences of the UANL, sponsor of the research that supports the present contribution, so that the data published herein may bring them professional and labor advantages.

Contribution by author

Horacio Villalón-Mendoza: conduction of the field and laboratory work, and drafting of the manuscript; Marcelo A. Castillo-Villarreal: field data collection and support in laboratory work; Fortunato Garza-Ocañas: laboratory work; José A. Guevara-González: review of literature, capture and analysis of the information, development of graphs, and drafting and review of the manuscript; Laura Sánchez Castillo: field work.

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