AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Colegio de Postgraduados

Yield evaluation of rocoto pepper (*Capsicum pubescens* R and P) with application of calcium carbonate in greenhouses

Piña-Ramírez, Francisco J.[1]; **García-Muñoz, Silvia A.**[1*]; **Ponce-García, Omar C.**[2]; **Soto-Parra, Juan M.**[1]; **Leyva-Chávez, Arwell N.**[1]; **Ortega-Rodríguez, Anabel**[1]

[1] Universidad Autónoma de Chihuahua, Facultad de Ciencias Agrotecnológicas, Av. Universidad, Campus l, Magisterial, Chihuahua, Chih., México,C. P. 31000.

[2] Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Av. Hidalgo No. 1213, Centro, Cd. Cuauhtémoc, Chih. México, C. P. 31500.

* Correspondence: smunoz@uach.mx

ABSTRACT

Objective: To evaluate if the application of calcium carbonate on the soil and to the leaf influences the weight and number of fruits in rocoto pepper grown under greenhouse conditions.

Design/Methodology/Approach: The study was carried out in the greenhouse of the Facultad de Ciencias Agrotecnológicas, of the Universidad Autónoma de Chihuahua. The Taguchi method was used to develop the 13 treatments, with two factors, five levels per factor, and five repetitions per treatment, using 65 plants under study. Data was analyzed using the quadratic response surface technique, fitting the surface to determine factor levels for optimal response.

Results: Reducing soil $CaCO_3$ by 9% and increasing leaf $CaCO_3$ by 100% was necessary to obtain the highest weight in the three harvests (234.8 g).

Findings/Conclusions: A rise in the number of rocoto peppers (from 59 to 70, in the three harvest periods) required an increase in the soil and foliar $CaCO_3$ by 8.5% and 100%, respectively.

Keywords: Taguchi L13, response surface, Factors and Levels.

Citation: Piña-Ramírez, F. J., García-Muñoz, S. A., Ponce-García, O. C., Soto-Parra, J. M., Leyva-Chávez, A. N., & Ortega-Rodríguez, A. (2023). Yield evaluation of rocoto pepper (*Capsicum pubescens* R and P) with application of calcium carbonate in greenhouses. *Agro Productividad*. https://doi.org/10.32854/agrop.v16i3.2413

Academic Editors: Jorge Cadena Iñiguez and Libia Iris Trejo Téllez

Received: October 24, 2022.
Accepted: February 28, 2023.
Published on-line: May 19, 2023.

Agro Productividad, 16(3). March. 2023. pp: 21-26.

This work is licensed under a Creative Commons Attribution-Non-Commercial 4.0 International license.

INTRODUCTION

The rocoto pepper (*Capsicum pubescens* R and P) is native to South America. It is characterized by a fleshy pulp and is very popular in Latin American cuisine. It thrives in cool places and at altitudes from 1,700 to 2,400 m. In Mexico it can be found in high, temperate, and cold areas of Michoacán, Querétaro, the State of Mexico, Puebla, and Chiapas (Pérez and Castro, 1998). It is sown in greenhouses and the open field, using different technological components. High-tech production records high yields with high quality in an environmentally friendly arrangement (Salazar *et al.*, 2012).

The demand for rocoto pepper has increased in the last ten years. This phenomenon has led to an increase in the quality and supply of the fruits throughout the year and has motivated the development of intensive greenhouse production systems to increase their quantity and quality (Pérez, 2002). In Mexico, production is carried out mainly from July to December, which results in an absolute shortage from January to June (Gasca, 2011). The optimum temperature for the development of the rocoto pepper is 18 to 22 °C during the day and 10 to 12 °C at night. Temperatures higher than 35 °C pose a risk of flower bud abortion. Another important factor for development is relative humidity: less than 40% humidity causes pollen dehydration, which results in low pollination and low seed formation (Pérez, 2002).

Calcium carbonate is obtained by grinding and micronizing limestone and is a by-product of cement production. It may contain calcium and magnesium, usually as oxides, carbonates, or hydroxides. The main use of calcium carbonate in agriculture is to "raise the pH of acid soils and reduce the aluminum (Al) concentration in the soil solution; poor crop growth in acid soils is mainly caused by soluble Al, which is toxic to the root system of many plants". (IPNI, 2019). Therefore, Osorio (2013) proposes the use of calcareous amendments to provide calcium to plants, favoring the production of crops, particularly those that have a high demand for Ca^{2+} and Mg^{2+}.

The amendments can contribute to the increase of calcium, magnesium, potassium, phosphorus, and sulfur in the soil, improving crop production. Calcium carbonate can be applied to the soil as a fertilizer, meeting the post-emergence calcium demand of crops. Meanwhile, soil fertilization can be complemented with foliar applications.

The low rainfall in the arid regions of northern Mexico causes a high level of calcium carbonate (from both calcareous and non-calcareous origin) in the soil. However, the high content of sodium ions —whose excessive presence displaces calcium and magnesium— in the irrigation water has affected the permeability and has caused infiltration problems in the soil. These soils are also characterized by high salinity and sodicity, which limits agricultural production in arid and semi-arid regions. These factors have increased because of an inadequate soil and irrigation water management (Schoups *et al.*, 2005; Corwin *et al.*, 2007; Li *et al.*, 2007).

In the state of Chihuahua, Mexico, peppers of the jalapeño, serrano, chilaca, and cayenne varieties are currently grown, while the rocoto pepper may be an option for greenhouse cultivation. The objective of the present work was to evaluate if the soil and leaf application of calcium carbonate (product obtained from the Chihuahua cement company) influences the weight and number of the rocoto pepper fruits under greenhouse conditions.

MATERIALS AND METHODS

The work was carried out with rocoto pepper plants that had already been established in sandy substrates in the greenhouse of the Facultad de Ciencias Agrotecnológicas of the Universidad Autónoma de Chihuahua. The greenhouse has an area of 760 m^2 and is equipped with a wet wall, extractors, heating, and a semi-automatic drip irrigation system. The rocoto pepper plants used had already been established in 40×40 cm black polyethylene bags, with a capacity of 16 L^{-1} (equivalent to 20 kg of sand substrate). The rows in which the bags with the substrate were placed were 50 cm apart from each other and included a 90-cm alley. For their part, the plants were 30 cm apart from each other. We used a drip irrigation system and applied the nutrient solution (fertigation) on a daily basis (Table 1).

Table 1. Amount of nutrients applied to the rocoto pepper crop.

N	P	K	Ca	Mg	Fe	Mn	Zn	B	Cu
Mg L^{-1}									
305	54	400	164	54	2	1	1	0.50	0.05

A Taguchi method with two factors and five levels per factor was established for the study, generating 13 treatments with five repetitions per treatment and using 65 experimental plants (each experimental unit consisted of one plant) (Table 2). Given the factorial nature of the Taguchi method employed, a complete quadratic response surface analysis was performed, fitting the surface to determine the factor levels for an optimal response (SAS, 1989).

The response variables were the fruit weight (g) and the number of fruits. The former was measured with a digital scale; the fruit weight of each treatment and each repetition was measured to obtain the average. The latter variable was determined by physical counting at the end of each harvest, while the fruit weight was measured.

RESULTS AND DISCUSSION

The average weight of the rocoto pepper fruits obtained in the three harvests was 195.5 g, while 12% of the fruits obtained an average weight of 209 to 234.8 g during the same period. This result indicates that the highest weight requires the application of 2,928.7 kg ha^{-1} of $CaCO_3$ to the soil and 26 L ha^{-1} of $CaCO_3$ on the leaves (Table 3).

Calcium is essential to maintain some physical properties of the horticultural products, including firmness, which is an important quality characteristic. Excessive softening is one of the main factors that reduces quality and limits the commercialization of fresh products (Pablo *et al.*, 2010). Another quality factor is weight, which is associated with decay during the post-harvest handling of the fruit (González *et al.*, 2009). Products treated with calcium lose less weight, because pectin allows calcium ions to increase the stability of cell walls; although plant cell walls are permeable to water, the disassembly of this structure is not reduced. The resistance of this structure to the water flow is increased (Pablo *et al.*, 2010).

The number of fruits in the three harvest periods had a range of 59 to 70 fruits (a 19% increase). Achieving that gain requires an increase in the amounts of $CaCO_3$ in the soil and the leaves, in a 9% and 100% rate, respectively (Table 4). Therefore, achieving the highest response in the number of peppers (70) requires an increase of $CaCO_3$ in the soil and in the leaves of 3,479.1 kg ha^{-1} and 25.6 L ha^{-1}, respectively. Valerio and Molina (2012) reported a significant response in rice yield with the application of Cal 56. Sánchez and Durand (2002) reported that Ca nitrate at 6% significantly increased the number of fruits in three mango cultivars, when Ca nitrate was combined with boron and applied to the soil after flowering.

CONCLUSIONS

Leaf applications of calcium carbonate during plant development improved the weight and number of rocoto peppers from 12% to 19%. Reducing the amount of $CaCO_3$ in the soil by 9% and raising the leaf $CaCO_3$ up to 100% increases the weight of the rocoto pepper by 12%. Increasing the number of peppers by 19% requires the application 9% and 100% of $CaCO_3$ to the soil and the leaves, respectively.

Table 2. Factors and levels for leaf and soil applications on rocoto pepper.

Factors	**Levels**				
	1	**2**	**3**	**4**	**5**
Calcium Oxide (CaO) kg ha^{-1} (Soil)	0.0	800	1600	3200	6400
Calcium Carbonate ($CaCO_3$) kg /1000 L^{-1} (Foliar)	0.0	4	8	16	32

The fertilizers used in the preparation of the nutrient solution were calcium nitrate (N 15.5%, Ca 19.0%), potassium nitrate (N 12.0%, K 45.0%), ultrasol MAP (N 12.0%, P 61.0%), sulfate magnesium (Mg 9.82%), solubor (B 20.5%), copper sulfate (Cu 25.5%), ferrous sulfate (Fe 20.0%), tradecorp (Mn 13.0%), zinc sulfate (Zn 36.0%). The content of the calcium carbonate used ($CaCO_3$; 99.8% purity, 59.52% CaO, 7.44% SiO_2, 2.09% Al_2O_3, 0.12% Na_2O, 0.09% Fe_2O_3).

Table 3. Maximum response surface[1] for weight in three rocoto pepper harvests under greenhouse conditions, with soil and leaves treated with calcium carbonate.

Regression		**Weight**	
		Factors	
		$CaCO_3$ Soil	**$CaCO_3$ Foliar**
		0.2055^{W}	0.1552
Linear (L)	0.0956^{W}		
Cuadratic (C)	0.6345		
Products	0.1513		
Model	0.1876	R^2 0.5943 C.V. 13.46	μ 195.5
Weight g	E.E.^{Z}	Kg ha^{-1}	L ha^{-1}
209.0	16.8	3200.0	12.8
211.0	17.1	3357.1	13.9
213.0	17.2	3423.0	15.2
215.0	17.1	3421.9	16.5
217.2	17.0	3383.7	17.9
219.5	16.9	3325.9	19.2
222.1	16.9	3256.2	20.5
224.9	17.2	3179.8	21.8
228.0	17.9	3098.9	23.0
231.3	19.1	3014.9	24.3
234.8	20.8	2928.7	25.6
Predicted fixed point		Critical values decoded	
209.78		4880.3	8.59

[x]Ridge analysis; μ Overall mean, C.V. Coefficient of variation, R^2 Coefficient of determination. [W] Probability of F: Pr≥0.05 Not significant, Significant 0.05≤Pr ≤0.01, highly significant Pr≤0.01. [Y] significant linear (L), quadratic (C) response (Pr>|t|) significant products of that nutrient with the rest; [Z] standard error.

Table 4. Maximum response surface[1] for number of peppers in three cumulative harvests under greenhouse conditions, with soil and leaves treated with calcium carbonate.

Regressión		**Number of chillies**	
		Factors	
		$CaCO_3$ Soil	**$CaCO_3$ Foliar**
		0.4083	0.3029
Linear (L)	0.1310		
Cuadratic (C)	0.5602		
Products	0.5598		
Model	0.3215	R^2 0.5052 C.V. 16.16	μ 57.0
Number of chillies	E.E.[Z]	Kg ha^{-1}	L ha^{-1}
59	5.89	3200.0	12.8
60	6.00	3384.4	13.8
61	6.04	3488.1	15.1
61	6.04	3537.8	16.4
62	6.01	3557.5	17.7
64	6.00	3560.6	19.0
65	6.01	3553.6	20.3
66	6.14	3540.3	21.7
68	6.40	3522.7	23.0
69	6.86	3502.0	24.3
70	7.53	3479.1	25.6
Predicted fixed point		Critical values decoded	
60		4882.5	9.16

[x]Ridge analysis; μ Overall mean, C.V. Coefficient of variation, R^2 Coefficient of determination. [W]Probability of F: Pr≥0.05 Not significant, Significant 0.05≤Pr≤0.01, highly significant Pr≤0.01. [Y] significant linear (L), quadratic (C) response (Pr>|t|), significant products of that nutrient with the rest; [Z]standard error.

REFERENCES

Corwin, D.L., Rhoades, J.D., Simunek, J. (2007). Leaching requirement for soil salinity control: Steady-state versus transient models. *Agric Water Manage. 90* (3). 165-180. Doi: 10.1016/j.agwat.2007.02.007

Gasca, P.R. (2011). Reflectancia en hojas de chile manzano (*Capsicum pubescens* R. y P.) para estimar contenido de nitrógeno. Tesis doctoral. Colegio de Postgraduados. Montecillo, Texcoco, México.

Gonzalez, A.G.A., Valenzuela, S.E., Lizardi, M.J., Goycoolea, F., Martínez, T.M.A., Villegas, O.M.A., Monroy, G.I.N., Ayala, Z.J.F. (2009). Effect of chitosan coating in preventing deterioration and preserving the quality of fresh-cut papaya 'Maradol'. *J. Sci. Food Agric. 89* (1). 15– 23.

IPNI. (14 de junio de 2019). Fuentes de nutrientes específicos. Carbonato de calcio, s/p. recovered from : http://www.ipni.net/specifics-es

Li, X., Wang, K, Song, Z., Zhang, B., Liu, D., Guo, Z. (2007). Assessment for salinized wasteland expansion and land use change using GIS and remote sensing in the west part of Northeast China. *Environ Monit Assess. 131* (1-3). 421-437.

Osorio, N.W. (2013). ¿Cómo determinar los requerimientos de cal del suelo? *Manejo Integral del Suelo y Nutrición Vegetal, 1* (5). 1-6.

Pablo, A., Hilda, C., Elisa, M., Laura, T., Analía, C., Alicia, Ch., Ariel, R.V. (2010). Effect of preharvest calcium applications on postharvest quality, softening and cell wall degradation of two blueberry (*Vaccinium corymbosum*) varieties. *Postharvest Biology and Technology. 58* (2). 98-103. Doi: 10.1016/j.postharvbio.2010.05.015

Pérez, G.M., Castro, R. (1998). Guía para la producción intensiva de chile manzano. Boletín de divulgación Núm.1. Programa Nacional de investigación en Olericultura. . 1ª ed. 17 p. Texcoco, Estado de Mexico. Universidad Autónoma Chapingo (UACH).

Pérez, G.M. (2002). Estudio genético y fisiológico del crecimiento, rendimiento y calidad del fruto de chile manzano (Capsicum pubescens R. y P.). Tesis Doctoral. Especialidad en genética. Colegio de Posgraduados. Montecillos, México.

Salazar, M.R., Cruz, M.P., Rojano, A.A. (2012). Eficiencia en el uso de la energía en invernaderos mexicanos. *Rev. Mex. Cienc. Agríc. 3* (4). 736-742.

Salazar, O.L.A., Ortega C.O.S. (2004). Efectos farmacológicos de la capsaicina, el principio pungente del chile. *Biología Scripta 1* (1). 7-14.

SAS. (1989). SAS/STAT User's guide. Version 6; SAS Institute. Cary, NC, USA: 1028-1056.

Schoups, G., Hopmans, J.W., Young, C.A., Vrugt, J.A., Wallender, W.W., Tanji, K.K., Panday, S. (2005). Sustainability of irrigated agriculture in the San Joaquin Valley, California. *Proc. Natl. Acad. Sci. 102* (43). 15352-15356. Doi: 10.1073/pnas.0507723102

Valerio, J., Molina, E. (2012). Evaluación de una fuente de enmienda líquida en el rendimiento del arroz en un Ultisol de la zona norte de Costa Rica. *Agronomía Costarricense. 36*(1). 89-96.

AGRO PRODUCTIVIDAD