Investigation note

Effect of thermotherapy on emergence and vegetative characteristics of genotypes of garlic

Rodolfo Velásquez-Valle[§]
Manuel Reveles Hernández

Experimental Field Zacatecas-INIFAP. Highway Zacatecas-Fresnillo km 24.5, Calera de VR, Zacatecas, Mexico. CP. 98500. (reveles.manuel@inifap.gob.mx).

[§]Corresponding author: velasquez.rodolfo@inifap.gob.mx.

Abstract

About 45% of the Mexican production of garlic is obtained in Zacatecas. Viral diseases of garlic can be transmitted by seed, thermotherapy has been used to reduce the viral concentration in garlic cloves; however, there is scarce local information about the impact of its impact on characteristics of plants originated from heat-treated bulbs; the purpose of this work was to determine the effect of heat treatment on the emergence and vegetative characteristics of 22 garlic genotypes. The garlic bulbs were preserved at 33 °C ±1 for six consecutive weeks. At the end of that period they were planted in the field. The emergence, height, neck diameter and number of leaves were recorded. The effect of the thermotherapy did not show a solid tendency, plants of seven heat-treated genotypes showed higher emergence and height values than those of their controls, while plants of only three and two genotypes from heat-treated bulbs had values of number of leaves and diameter of neck superior to those of their witnesses.

Keywords: emergence, height, neck diameter, number of leaves.

Reception date: February 2019
Acceptance date: March 2019

Approximately 45% of the Mexican production of garlic (*Allium sativum* L.) is contributed by the state of Zacatecas, which is produced in 2 000 ha (Reveles-Hernández *et al*., 2014). The production of this bulb in the region is confronted by diseases such as white rot (*Sclerotium cepivorum* Berk.) and viral infections, Velásquez-Valle *et al.* (2010) reported in plots of garlic the presence of several viruses, some of which could be transmitted through the material used as seed. One of the means of handling viruses is the use of high temperature to eliminate or reduce the 'viral load' prior to the cultivation of meristems; an alternative available to producers is the application of high temperature directly to garlic bulbs without damaging their capacity for germination or further development (Velásquez-Valle *et al.*, 2017).

Perotto *et al*. (2010) indicated the negative effect of the viral infection on the number and weight of teeth, size and weight of bulb in varieties of garlic of the purple and white types, although the severity was lower in the purple varieties. There is little regional information on the effect of thermotherapy on agronomic characteristics of plants emerged from heat-treated bulbs. The objective of this work was to evaluate the effect of heat treatment on the emergence and vegetative characteristics of 22 garlic genotypes.

The work was carried out in a plot of the Experimental Field Zacatecas (INIFAP) located in the municipality of Morelos Zacatecas (latitude 22.908611, length -102.659444, altitude 2 197 m) during the 2013-2014 crop cycle. Once the heat treatment was finished, the bulbs were shelled and planted in two double-row beds in experimental plots of four threads of one m in length with a useful plot in the two central furrows, eliminating the plants in the initial and final 25 cm each thread

Four bulbs of each of 22 genotypes of the mottled, white and purple types (Table 1), of 8 gauge, were selected at random, with a visual index of dormancy that fluctuated between 80 and 87% (Burba *et al.*, 1983) and from asymptomatic plants. The bulbs were numbered and kept for six consecutive weeks at a temperature of 33± 1 °C in an Mca bacteriological stove Felisa Mod. FE 131 111 Series. Additionally, a similar number of bulbs of each genotype were kept at room temperature to be used as controls.

Table 1. Type of garlic and geographical origin of the 22 genotypes used in the current work.

Line	Origin	Type	Line	Origin	Type
1	Zacatecas	Marbled	2	Zacatecas	Marbled
3	Zacatecas	Marbled	4	Zacatecas	Marbled
5	Aguascalientes	White	6	Zacatecas	Marbled
7	Zacatecas	Marbled	8	Zacatecas	Marbled
9	Zacatecas	Marbled	10	Zacatecas	Marbled
11	Zacatecas	Marbled	12	Zacatecas	Marbled
13	Zacatecas	Marbled	14	Zacatecas	Marbled
15	Zacatecas	Marbled	16	Zacatecas	Marbled
17	Aguascalientes	White	18	Zacatecas	Marbled
19	Guanajuato	Purple	20	Guanajuato	Purple
21	Guanajuato	Purple	22	Guanajuato	Purple

The plots of treated bulbs were planted in beds contiguous to those of their respective witnesses. The number of teeth planted in each useful plot was recorded. The emergence of seedlings (%) was estimated three weeks after planting. The height of plant (cm), diameter of neck (mm) and number of leaves were obtained in four plants of each variety in both modalities (heat treated and control). To compare the values obtained between the treated and untreated plants, the Student test (0.05%) was used (Olivares, 2013).

The emergence of garlic seedlings of heat-treated bulbs was significantly superior to their controls in 9 of the 22 genotypes, in only two of them the emergence of seedlings from control bulbs was greater than that of the heat-treated bulbs. However, 50% of the genotypes did not detect a difference in this variable between thermo-treated and control bulbs (Table 2). The range of emergency percentages resulted from 20.8 to 93.3 and from 5.6 to 89.6% in thermo-treated and control bulb teeth, respectively. The greatest differences in emergency percentage favorable to heat-treated teeth were 41.3, 35.6 and 31.2% in genotypes 11, 1 and 5, respectively. The teeth of the genotypes of the purple type showed, in general, a low percentage of emergence, although in the genotype 21 of this type of garlic, the percentage of emergence of control seedlings was significantly higher than that of heat-treated bulbs.

Table 2. Emergence of 24 genotypes of garlic seedlings from heat-treated bulbs and their controls.

Line	Condition	Emergency (%)	Line	Condition	Emergency (%)
1	Thermotreated	93.3*	2	Thermotreated	79.1*
	Control	57.7		Control	66.5
3	Thermotreated	79.8*	4	Thermotreated	86.6*
	Control	89.6		Control	61.9
5	Thermotreated	92.9*	6	Thermotreated	76.2 ns
	Control	61.7		Control	64.5
7	Thermotreated	58.6 ns	8	Thermotreated	88.1*
	Control	55.9		Control	60.5
9	Thermotreated	90.2 ns	10	Thermotreated	90.1 ns
	Control	78.3		Control	59.9
11	Thermotreated	82.1*	12	Thermotreated	70 ns
	Control	40.8		Control	79.2
13	Thermotreated	79.4*	14	Thermotreated	88.3 ns
	Control	50		Control	82
15	Thermotreated	26.9*	16	Thermotreated	63.7 ns
	Control	5.6		Control	73.1
17	Thermotreated	31.4 ns	18	Thermotreated	43.7*
	Control	32.3		Control	14.1
19	Thermotreated	55.6 ns	20	Thermotreated	24.6 ns
	Control	55.2		Control	48.1
21	Thermotreated	20.8	22	Thermotreated	38.8 ns
	Control	51.7		Control	40.5

The height of the plants from heat-treated bulbs was significantly higher than that of their controls in 13 of the 22 genotypes of garlic, the difference in height favorable to plants originated from heat-treated bulbs, in terms of percentage, ranged between 16.8 and 37.5% (genotypes 16 and 3, both of the mottled type), in only one genotype, from Guanajuato, of the purple type, the opposite effect was observed; that is, the height of the control plants was higher than that of plants from heat-treated bulbs. In eight genotypes no differences were observed in the height of plants from heat-treated bulbs and their controls (Table 3).

Table 3. Height of plants of 24 garlic genotypes from heat-treated bulbs and their controls.

Variety	Condition	Height (cm)	NH[1]	Variety	Condition	Height (cm)	NH
1	Thermotreated	20.1*	4.8 ns	2	Thermotreated	19.9*	4.6 ns
	Control	14.5	4.9		Control	14.9	4.8
3	Thermotreated	25.3*	4.3*	4	Thermotreated	19.7*	4.7*
	Control	15.8	5.2		Control	14.3	5.6
5	Thermotreated	18.9*	5.2*	6	Thermotreated	18.4*	4.7 ns
	Control	14.6	4.4		Control	14.2	5.4
7	Thermotreated	17.7 ns	4.5 ns	8	Thermotreated	20.1 ns	5.3 ns
	Control	17.9	5.3		Control	18.4	5.6
9	Thermotreated	17.2 ns	4.6*	10	Thermotreated	18.2*	4.9 ns
	Control	15.1	5.2		Control	15	5.5
11	Thermotreated	18.5*	5.3*	12	Thermotreated	16.4 ns	4.8 ns
	Control	13.9	4.3		Control	12.8	4.6
13	Thermotreated	17.3*	4.7 ns	14	Thermotreated	17*	4.1*
	Control	13.6	5		Control	12.6	3.6
15	Thermotreated	15.5 ns	4.2 ns	16	Thermotreated	26.2*	4.6 ns
	Control	13.8	4.1		Control	21.8	4.8
17	Thermotreated	17.7*	4.6 ns	18	Thermotreated	22.8 ns	3.8 ns
	Control	12.3	4.6		Control	22.8	3.8
19	Thermotreated	12*	5.3 ns	20	Thermotreated	28.6 ns	4*
	Control	9	5.9		Control	29.8	6.2
21	Thermotreated	28.7 ns	4.2 ns	22	Thermotreated	25.5*	4.4 ns
	Control	27.9	4.5		Control	32.4	3.9

[1]NH= number of leaves.

In seven of the 22 genotypes of garlic, significant differences were found in the average number of leaves between plants of heat-treated bulbs and their controls; however, in only three of them; genotypes the difference was favorable to heat-treated bulb plants (Table 3). No significant difference was detected in the neck diameter of plants from heat-treated and control bulbs belonging to 17 of the 22 garlic genotypes, only five genotypes (12, 15, 18, 21 and 22) exhibited a significant difference in this variable, although this difference was only favorable to heat-treated bulb plants of two genotypes, 12 and 15, both coming from Zacatecas and the variegated type; this difference represented an increase of 38.7 and 18.6% with respect to the control (Table 4).

Table 4. Diameter of the neck of plants belonging to 24 genotypes of garlic from heat-treated bulbs and their controls.

Variety	Condition	Diameter of neck (mm)	Variety	Condition	Diameter of neck (mm)
1	Thermotreated	9.1 ns	2	Thermotreated	8.5 ns
	Control	8		Control	8.3
3	Thermotreated	8.5 ns	4	Thermotreated	8.1 ns
	Control	8.9		Control	9.5
5	Thermotreated	7.9 ns	6	Thermotreated	8.8 ns
	Control	8.5		Control	8.6
7	Thermotreated	8.9 NS	8	Thermotreated	9.8 ns
	Control	9.4		Control	9.5
9	Thermotreated	7.4 ns	10	Thermotreated	9 ns
	Control	7.9		Control	8.6
11	Thermotreated	7.4 NS	12	Thermotreated	8.6*
	Control	7.6		Control	6.2
13	Thermotreated	9.3 ns	14	Thermotreated	8.4 ns
	Control	8.1		Control	7.5
15	Thermotreated	10.2*	16	Thermotreated	8.4 ns
	Control	8.3		Control	8.1
17	Thermotreated	7.2 ns	18	Thermotreated	5.5*
	Control	7.3		Control	8
19	Thermotreated	7 ns	20	Thermotreated	9.2 ns
	Control	7		Control	10.3
21	Thermotreated	7.6*	22	Thermotreated	5.5*
	Control	9.8		Control	9.8

The complete elimination of diseases of viral origin in garlic plants is difficult because these pathogens accumulate in the bulbils (Pérez-Moreno *et al.*, 2013), consequently, thermotherapy has been proposed as an intermediate step in the process of obtaining virus-free seedlings (Ucman *et al.*, 1998).

In the emergency and height variables, 11 and eight genotypes were registered respectively, where their average values were not significantly different from their respective controls; however, in 22 of 25 cases in which the comparison was significant for these variables, the plants from heat-treated bulbs outperformed the control plants.

On the other hand, it highlights that the heat treatment had less effect on the variables of number of leaves and diameter of the neck where 15 and 17 of the 22 garlic genotypes evaluated showed no significant difference between plants from heat-treated bulbs and their controls. In 7 out of 12 cases where the comparison was significant, the control plants outperformed the thermo-treated ones in the two mentioned variables.

The response of the genotypes was more consistent within the emergency variables and plant height where the genotypes 1, 2, 3, 4, 5, 11 and 13 appear as outstanding for both characteristics; however, genotypes 5 and 11 originated in heat-treated bulbs and were outstanding in emergence, height and number of leaves. These results are the product of an evaluation cycle and should be repeated before reaching definitive conclusions. It is recommended to include a greater number of genotypes of the white and purple types.

The results previously obtained in the reduction of 'viral load' showed little change in the viral incidence before and after heat treatment (53.5 and 45.1% respectively) (Velásquez-Valle *et al.*, 2017), it is possible that the inconsistencies in terms of the reduction of 'viral load' and the effect on the emergence characteristics of plants and vegetative may also be related to the nature of the heat treatment, so a broader range of temperature and exposure periods should be explored as far as conditions permit of the bulbs.

Cited literature

Burba, J. L.; Müller J. J. V. y Casali V. W. D. 1983. Relaciones entre el índice visual de superación de dormición (IVD) en ajo (*Allium sativum* L.) con el tamaño y posición de bulbillos. Rev. Cienc. Agropec. 4:99-102.

Olivares, S. E. 2013. Programas estadísticos. Versión 1.4. Facultad de Agronomía. Universidad Autónoma de Nuevo León.

Pérez-Moreno, L.; Navarro-León, M. J.; Ramírez-Malagón, R.; Mendoza-Celedón, B.; Núñez-Palenius H. G. y León-Galván, M. F. 2013. Detección de complejos virales en ajo por elisa y confirmados por RT-PCR. Interciencia. 38:364-369.

Perotto, M. C.; Cafrune, E. E. y Conci, V. C. 2010. The effect of additional viral infections on garlic plants initially infected with *Allexiviruses*. Eur. J. Plant Pathol. 126:489-495.

Reveles-Hernández, M.; Velásquez-Valle, R. y Cid-Ríos, J. A. 2014. Barretero, variedad de ajo jaspeado para Zacatecas. Campo Experimental Zacatecas-Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). Calera, Zacatecas, México. Folleto técnico núm. 61. 34 p.

Ucman, R.; Žel, J. and Ravnikar M. 1998. Thermoterapy in virus elimination from garlic: influences on shoot multiplication from meristems and bulb formation *in vitro*. Scientia Horticulturae 73:193-202.

Velásquez-Valle, R.; Chew-Madinaveitia, Y. I.; Amador-Ramírez, M. D. y Reveles-Hernández, M. 2010. Presencia de virus en el cultivo de ajo (*Allium sativum* L.) en Zacatecas, México. Rev. Mexicana de Fitopatología 28:135-143.

Velásquez-Valle, R.; Reveles-Hernández, M.; Chew-Medinaveitia, Y. I. y Reveles-Torres, L. R. 2017. Efecto del tratamiento térmico sobre la presencia de virus en bulbos de ajo (*Allium sativum* L.). Rev. FCA Uncuyo. 49:157-165.