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Solutions and washing times of phenolic foam in lettuce seedlings production

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Abstract

The main characteristics of the phenolic foam are inherent to a substrate of excellent quality such as sterility, excellent aeration and high load-bearing capacity. However, as it comes from a phenolic resin, the foam has some residues that can affect the development of plants. Thus, this work aimed to evaluate different treatments for washing phenolic foam under the germination and initial growth of lettuce seedlings in two immersion times. The experimental design was completely randomized (DIC), in a 5x2 factorial scheme, containing four replications with 56 plants per plot. Each repetition was composed of a phenolic foam board. The experimental factors consisted of different substances: caustic soda (NaOH), pint lime ($CaOH_2$), citric acid ($C_6H_8O_7$), vinegar (CH_3COOH) and water in solution with distilled water, and two immersion times (30 minutes and 18 hours). For the witness treatment, there was no immersion. After 18-hour immersion, the treatment with citric acid presented the best development for height and biomass in the lettuce seedlings. On the other hand, the 4,0% vinegar pretreatment was not considered viable for phenolic foam for any of the times analysed. There was a significant decrease in seedling biomass when no treatment in the foam was carried out before sowing the lettuce seeds. The caustic soda presented lower results for emergence speed index, fresh aerial biomass, height and number of leaves for the 18-hour immersion compared to the 30-minute immersion.

Keywords: Acids. Bases. Emergency. *Lactuca sativa*. Immersion time.

Introduction

Lettuce (*Lactuca sativa* L.) is the most important leafy vegetable in the world and the most commercialized in Brazil, being consumed mainly in natura, prepared in salads (SALA; COSTA, 2012, SANTI et al., 2013). It is the most popular species among those in which the leaves are eaten raw and still fresh (COMETTI et al., 2004).

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Depending on the demand, lettuce production is needed throughout the year. However, factors such as high and low temperatures, above 20,0ºC and below 10,0ºC, acidic and alkaline soils, soils deficient in nutrients and compacted or very clayey soils limit the production of this vegetable under the desirable qualitative characteristics: heads with greater fresh weight, head compactness, plants with resistance to pests and diseases and the incidence of physiological anomalies (TANAMATI, 2012).

For lettuce growing, the hydroponic cultivation system has been currently gaining space due to high technology and productivity. According to Furlani et al. (1999), hydroponic is an alternative cultivation technique at which the soil is replaced by an aqueous solution containing only the mineral elements essential to plants. This technique has been associated with the production of vegetables of higher sanitary quality and yield than those cultivated in a conventional way (CARRASCO, 2004).

According to Resh (1997), the great increase in hydroponic production when compared to the conventional system is due to several factors, especially the ones related to physical, biological and nutritional aspects of the soil. Soils may lack some nutrients and be of a poor composition, which can prevent plant root growth besides spreading diseases.

In order to obtain good quality seedlings for hydroponics and guarantee the success of commercial crops, some special care is necessary, such as attention to substrate characteristics, water needs and mineral nutrition of the seedlings (TRANI et al., 2004). The production of seedlings of high quality contributes to resistance against mechanical damages during transplantation and to good adaptability to the new environment. As a result, there is reduction in the production cycle, in addition to greater resistance to diseases (MENEZES JUNIOR et al., 2002; CAÑIZARES et al., 2002).

The substrate is the most sensitive and complex component of the seedling production system, since any variation in its composition can alter the final process of seedling production, from the non-germination of the seeds to the development of the plants (MINAMI, 1995). According to Gonçalves (1994), the main functions of the substrate are to nurture the plants and to supply nutrients and aeration, allowing gas exchange in the root system. It consists of a solid (mineral and organic particles) and a gaseous part formed by the pores, which can be occupied by water or air.

The substrate must be abundant, of low-cost, free from pests, phytopathogens, and toxic substances, it must allow sterilization without changing property or quality, be uniform and thoroughly stable, not presenting unpleasant odours nor leaving residues that may harm the environment or humans, it must be light, able to be stored for a long time without losing its characteristics, and promote proper integration with the root system, not sticking to the container in order to successfully enable its removal and handling (MEDEIROS et al., 2007).

Phenolic foam stands out among the most used substrates, due to its good moisture retention capacity, excellent aeration and low possibility of disintegration in its administration (BURES, 1997).

Martinez and Silva Filho (1999) point out that besides the inherent characteristics of the physical and chemical properties of the phenolic foams, they take small spaces for storage and are of low cost. For some agricultural crops, the foam has already been studied and a similar behaviour to the development of plants has been observed in relation to the procedures usually adopted (MATIAS et al., 1999; PAULUS et al., 2005; FERNÁNDEZ et al., 2007).

Phenolic foam is a compound based on phenolic resin formed from a chemical reaction with organic or inorganic acids. For its best use in agriculture, pH correction is recommended to leach and neutralize the acid waste. This operation is usually carried out by washing it with water or with solutions of calcium carbonate ($CaCO_3$), magnesium carbonate ($MgCO_3$), sodium carbonate (Na_2CO_3), calcium oxide (CaO), or calcium hydroxide ($Ca(OH)_2$) (SILVA et al., 2012). The acidic residues resulting from the manufacturing process impair germination, emergence and seedling growth (PAULUS et al., 2005). According to Bezerra Neto et al. (2010), low pH from non-washed foam residues results on seeds of low germination rate; furthermore, when they germinate, they die early, due to the difficulty in absorbing nutrients.

Aiming to obtain a more efficient pretreatment for the use of phenolic foam in the production of lettuce seedlings, this study addressed the evaluation of different treatments in the washing of phenolic foam, under germination and initial growth of lettuce seedlings in two immersion times.

Material and methods

Characterization of the experimental area

The experiment was carried out in a greenhouse in the biotechnology sector of the Federal Institute of Education, Science and Technology of Southern Minas Gerais, Muzambinho-MG, from October to November 2018.

Treatments and experimental design

The experimental design was completely randomized (DIC), in a 5x2 factorial scheme, containing four replications with 56 plants per plot. Each repetition was composed of a phenolic foam board. The experimental factors consisted of different substances: caustic soda (NaOH), paint lime ($CaOH_2$), citric acid ($C_6H_8O_7$), commercial ethanol-made vinegar (CH_3COOH), and water in solution with distilled water and two immersion times (30 minutes and 18 hours). A witness treatment was added, for which there was no immersion. The sodium hydroxide was placed in a 0.1N solution and its pH was used as a standard to determine the concentration of paint lime. The experiment used the commercial vinegar, and its pH was used as a standard to determine the concentration of citric acid. Table 1 shows the concentrations and pH for the solutions.

Table 1 – Concentration of solutes in solution and pH of the pre-established treatments for washing phenolic foam in the production of lettuce seedlings at different immersion times (IFSULDEMINAS, 2018).

Solutes	pH	Concentration
Caustic soda	12.7	3.99 g L^{-1}
Paint lime	12.5	3.3 g L^{-1}
Ethanol-made vinegar	2.7	40 mL L^{-1}
Citric acid ($C_6H_8O_7$)	2.7	3.35 g L^{-1}
Water	7.4	1.0 L

Source: Elaborated by the authors (2018)

Experiment installation and conduction

The phenolic foam was separated accordingly to the pre-established treatments and it was placed in plastic dishes with 500.0 mL of the solution for washing. The volume was sufficient to maintain waterlogging during the periods of 30 minutes and 18 hours. The time of 30 minutes was considered due to the literature that uses this time for washing in most of the tests, and the time of 18 hours was considered as a period at which it would be possible to obtain a stable result.

After the period of exposure to the solutions, the plates were washed in immersion with 3.0 L of water from a treatment plant located in the Federal Institute of Education, Science and Technology of South of Minas Gerais. The procedure was repeated 4 times with a total time of 80 minutes.

After removing the solutes, the foams were perforated with a sharp object and sown with lettuce cv. Vanda. The drilled hole was covered with vermiculite, to provide the seeds with the necessary darkness for the radicle emission. The foam moisture was brought to field capacity through watering cans. The foam humidity was increased to a level at which all the content was retained by the foam. The humidity was maintained by water for five days. From the 5th to the 11th day, a nutrient solution was applied, according to Furlani et al. (1999), at 25.0% concentration, then the solution was conducted at 50.0% salts until the end of the experiment.

Characteristics evaluated

The seedlings were removed from the greenhouse after 21 days. The percentage of emergence, emergence speed index (ESI), number of leaves, plant height, fresh biomass and dry biomass of the aerial part and root system and diameter were evaluated.

To determine the biomasses, an analytical scale was used. The drying of the samples to determine the dry biomass was conducted through an incubator with forced air circulation for a period of 24 hours. The diameter was measured with a digital caliper MTX-316119 on the seedling neck and the height was obtained with a 30.0 cm ruler.

The ESI was evaluated during the experiment, with daily evaluations, from day one, when the first seeds emit visible loop, until the day of the last test count. For the calculation, the equation proposed by Maguire (1962) was used:

$$ESI = (E1/N1) + (E2/N2) + \ldots + (Emn/Nn) \qquad (1)$$

at which: ESI = emergency speed index; E = number of normal seedlings computed in the counts; N = number of days from sowing to 1st, 2nd... 21st evaluation.

Statistical analysis

The data obtained were subjected to analysis of variance with the use of the statistical software SISVAR (FERREIRA, 2011), with the significant difference between treatments being determined by the F test. By detecting differences between treatments, the means were compared through the Scott-Knott test at the 5% probability level.

Results and discussion

The data regarding the emergency speed index are shown in Table 2. For the variable, there was interaction between the factors. For the immersion time, only citric acid had a better average in 18 hours compared to 30 minutes. In the other treatments, there was no significant difference in the time factor.

Table 2 – Lettuce cv emergence speed index. Vanda sown in phenolic foam treated with different solutes in solution at different immersion times (IFSULDEMINAS, 2018).

Treatments	ESI	
	Immersion times	
	30 min	**18 hours**
Non-washed	12.13Ba	12.13Ba
Treated water	15.7Aa	15.61Aa
Ethanol-made vinegar	0.0Da	0.0Ca
Citric acid	10.13Cb	14.65Aa
Paint lime	13.37Ba	14.37Aa
Caustic soda	12.69Ba	11.9Ba
CV (%)	10.53	

(*) Means followed by the same lowercase letter in the row and uppercase in the column do not differ at the 0.05 level of significance by the Scott-Knott test.

Source: Elaborated by the authors (2018)

In 30 minutes, the solution with water showed a higher average, differing from the other treatments. However, when the phenolic plates were subjected to 18 hours in spite of the water having the highest ESI, it did not differ significantly from citric acid and paint lime. There was no emergence of lettuce seeds in the phenolic foam plates treated with vinegar for any of the immersion times. The other ESI values were within the exposed by Marini et al. (2008) for lettuce culture.

The results found for the number of leaves, height and fresh biomass of the aerial part of the other treatments had interactions between the factors studied and are shown in Table 3.

For all variables, the treatment without washing provided the lowest averages of number of leaves, height and fresh biomass of the aerial part (FBAP). Similar results were obtained by Bezerra Neto et al. (2010) who, testing different concentrations of sodium hydroxide and potassium dioxide, concluded that pretreatment of the phenolic foam is needed, since it presents a pH under 1.0 in the selling condition, that is, far from the range required by the lettuce, which, according to Filgueira (2007), it is between the pH values of 6.0 and 6.7.

Table 3 – Number of leaves, height and fresh shoot biomass of the aerial part (FBAP) of the lettuce cv. Vanda sown in phenolic foam treated with different solutes in solution at different immersion times (IFSULDEMINAS, 2018).

Treatments	N. of Leaves		Height (cm)		BFPA (g)	
	Immersion times		Immersion times		Immersion times	
	30 min	**18 hours**	**30 min**	**18 hours**	**30 min**	**18 hours**
Non-washed	2.92 Da	2.92 Da	5.82 Ca	5.82 Da	0.220 Ba	0.220 Ba
Treated water	3.75 Aa	3.33 Bb	8.13 Ba	7.89 Ba	0.490 Aa	0.410 Aa
Citric acid	3.47 Ba	3.55 Aa	8.97 Ab	9.49 Aa	0.440 Aa	0.500 Aa

Treatments	N. of Leaves		Height (cm)		BFPA (g)	
	Immersion times		Immersion times		Immersion times	
	30 min	18 hours	30 min	18 hours	30 min	18 hours
Paint lime	2.99 Db	3.14 Ca	5.57 Cb	6.54 Ca	0.300 Ba	0.340 Ba
Caustic Soda	3.25 Ca	2.97 Db	8.09 Ba	7.12 Db	0.510 Aa	0.300 Bb
CV (%)	18.57	18.57	29.32	29.32	28.8	28.8

(*) Means followed by the same lowercase letter in the row and uppercase in the column do not differ at the 0.05 level of significance by the Scott-Knott test.

Source: Elaborated by the authors (2018)

In the treatment with citric acid, no difference was found for the number of leaves as a result of the immersion time. On the other hand, when using sodium hydroxide and water, the best results for the immersion time of 30 minutes were found. In this test, only the paint lime showed better results for the variable 18-hour immersion compared to the 30-minute immersion.

For the 18-hour immersion time, the citric acid as a solute provided higher average for the number of leaves and it differed from the others. Considering the 30-minute time, the best average for the number of leaves was obtained by using water as the only component of the solution in the immersion and it presented a difference compared to all the other treatments, followed by citric acid and caustic soda. The treatment without washing the plate and the paint lime provided the lowest averages and it did not differ from each other. Different results were found by Pessoa et al. (2007), who tested different concentrations of sodium hydroxide and water for 30 minutes and obtained better results in the use of the base for number of leaves.

Considering the immersion time of 18 hours, the highest average for the variable number of leaves was obtained when citric acid was used in the solution, followed by water and paint lime, which differed from each other, and among the other treatments that did not show significant difference from each other.

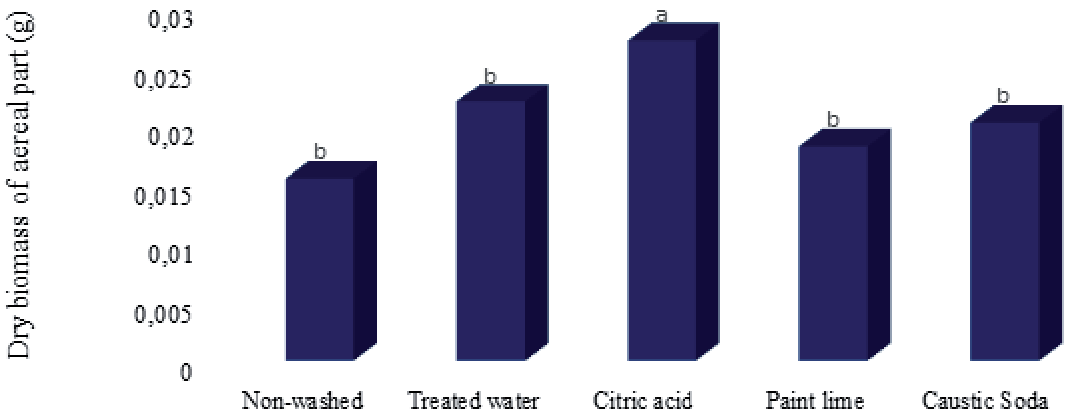
For the plant height variable, regardless of time, the highest averages were obtained with the use of citric acid as a solute in the wash.

Considering the fresh biomass, only sodium hydroxide presented a significant difference when the immersion time increased. For the 18-hour time, the variable presented lower mean when compared to 30-minute time.

For the 18-hour immersion time, the lowest averages found for fresh biomass were for sodium hydroxide and paint lime, which did not differ from the control without washing and differed from the other treatments. The increase in time may have significantly increased the pH of the foam promoted by the bases, which hindered the development of the seedlings. For the 30-minute period, only the hydrated lime treatment resembled the witness and differed from all other treatments. The increase in pH may also have been the reason for that result.

For the variable dry biomass of the aerial part (FIGURE 1), regardless of time, the highest means were obtained with the use of citric acid as a component of the solution in which the foam board was immersed.

Figure 1 – Dry biomass of the aerial part of lettuce cv. Vanda in phenolic foam submitted to treatments with different solutions for its washing. The means followed by the same letter did not differ from each other by the Scott-Knott test at the level of 0.05 (IFSULDEMINAS, 2018).



Source: Elaborated by the authors (2018)

Due to exposure during immersion of the solution containing the acid, it is suggested that the citric acid may have remained in the foam in small concentrations, which caused some organic reactions that promoted better plant development. This result supports the hypothesis of Guppy et al. (2005) that some acids have functional carboxylic radicals that make them capable of forming organic complexes with Al, Fe, Ca and Mg.

Conclusion

The treatment with citric acid provided the highest growth in height and dry biomass in the lettuce seedlings for 18-hour immersion.

The 4.0% vinegar concentration is not a viable choice as a pretreatment for phenolic foam in any of the times analysed.

There is a 56.0% decrease in the fresh biomass of the seedlings when no treatment is adopted in relation to caustic soda for the 30-minute time and in relation to citric acid for the 18-hour treatment. For dry biomass, the decrease is 42.0% for citric acid.

The caustic soda obtained lower results for emergence speed index, fresh aerial biomass, height and number of leaves for the 18-hour period compared to the 30-minute period.

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Soluções e tempos de lavagem de espuma fenólica na produção de mudas de alface

Resumo

A espuma fenólica possui as principais características inerentes a um substrato de ótima qualidade, como esterilidade, excelente aeração e alta capacidade de sustentação. No entanto, por ser proveniente de uma resina fenólica, a espuma apresenta alguns resíduos que podem afetar o desenvolvimento das plantas. Neste sentido, o presente trabalho teve o objetivo de avaliar diferentes tratamentos na lavagem da espuma fenólica sob a germinação e crescimento inicial de mudas de alface em dois tempos de imersão. O delineamento experimental foi inteiramente casualizado (DIC), em esquema fatorial 5x2, contendo quatro repetições com 56 plantas por parcela. Cada repetição foi composta por uma placa de espuma fenólica. Os fatores experimentais consistiram em diferentes substâncias: soda cáustica (NaOH), cal de pintura ($CaOH_2$), ácido cítrico ($C_6H_8O_7$), vinagre (CH_3COOH) e água em solução com água destilada e dois tempos de imersão (30 minutos e 18 horas). Foi acrescentado um tratamento testemunha em que não houve nenhuma imersão. Com imersão de 18 horas, o tratamento com ácido cítrico apresentou o melhor desenvolvimento em altura e biomassa nas mudas de alface. O vinagre 4,0% não é viável como pré-tratamento em espuma fenólica em nenhum dos tempos analisados. Existe um decréscimo significativo na biomassa das mudas quando não é adotado nenhum tipo de tratamento na espuma antes de semear as sementes de alface. A soda cáustica obteve menores resultados para índice de velocidade de emergência, biomassa fresca parte aérea, altura e número de folhas no tempo de 18 horas quando comparados ao tempo de 30 minutos.

Palavras-chave: Ácidos. Bases. Emergência. *Lactuca sativa*. Tempo de Imersão.

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