https://doi.org/10.18406/2316-1817v16nunico20241808 e-ISSN 2316-1817

Development of eggplant seedlings under different doses of biostimulant derived from *Ascophyllum nodosum*

Dênis Antônio Rocha Júnior[1]; Juvenal Rodrigues Silva Júnior[2]; José Augusto Pereira Neto[3]; João Paulo Mendes Ferreira[4]; Filipe Cogo Andrade[5]; Luis Lessi dos Reis[6]

[1] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas (IFSULDEMINAS) – Campus Machado, graduando em Engenharia Agronômica.; denis.junior@alunos.ifsuldeminas.edu.br

[2] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas (IFSULDEMINAS) – Campus Machado, juvenal.rodrigues@alunos.ifsuldeminas.edu.br;

[3] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas (IFSULDEMINAS) – Campus Machado, jose1.neto@alunos.ifsuldeminas.edu.br;

[4] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas (IFSULDEMINAS) – Campus Machado, joao.ferreira@alunos.ifsuldeminas.edu.br;

[5] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas (IFSULDEMINAS) – Campus Machado, fhilipe.andrade@alunos.ifsuldeminas.edu.br

[6] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas (IFSULDEMINAS) – Campus Machado, Professor Doutor. luis.reis@ifsuldeminas.edu.br

Received in: 15/04/2023
Accepted in: 05/11/2023

Abstract

Eggplant (*Solanum melongena* L.) belongs to the Solanaceae family and is among the 10 most consumed vegetables in Brazil. Among the cultivation systems, the production of seedlings is one of the most important steps to obtain quality plants and to reduce dependence on chemical products, in addition to ensuring crop stability. Currently, biostimulants are being used to improve agricultural performance. *Ascophyllum nodosum* L. algae are the most used for this purpose, being a source of organic matter, amino acids, carbohydrates, and nutrients that can favor plant development. This study aimed to evaluate eggplant seedlings development under different concentrations of the Acadian® biostimulant. The experimental design was conducted in randomized blocks and included five treatments, which consisted of doses of: 0, 3, 6, 9, and 12 mL p c L^{-1} of water, with 10 replications. The 'Classic F 1' hybrid eggplant seeds were used. Then, 34 days after sowing, the following morphological analyses were performed: plant height, root length, stem diameter, and root and shoot dry mass. The results were subjected to analysis of variance and regression analysis using the Sisvar statistical analysis program. The use of the biostimulant derived from *Ascophyllum nodosum* can increase the growth and development of plant height, root length, stem diameter, and root and shoot dry mass during the production phase of eggplant seedlings.

Keywords: *Ascophyllum nodosum* L.; *Solanum melongena*; Seedling production; Microorganisms; Sustainability.

Introduction

Eggplant (*Solanum melongena* L.) is a vegetable plant belonging to the Solanaceae family that bears a fleshy, berry-like fruit presenting varied shape and colors, being used in salads, soups, and preserves preparations. In addition, due to its nutraceutical properties, it can be used to formulate medicines and cosmetics, and is increasingly present in the diet and daily life of Brazilians, which means expanded marketing possibilities.

Among the cultivation systems, the success of vegetable production begins in the nurseries, since high-quality seedlings guarantee the uniformity and stability of the crop, optimizing the development and yield of the plants in the field (BHARATHI, RAVISHANKAB, 2018).

Seedling production is one of the most important stages in the vegetable production chain, as it will directly influence crop yield (CAMPANHARO et al., 2006). In this sense, healthy seedlings can increase production and promote early harvesting, whereas poorly formed seedlings can compromise plant development, negatively influencing production and the final quality of the product (GUIMARÃES, ECHER, MINAMI, 2002).

Currently, transplanting seedlings is the most widely used method in olericulture. To this end, the commercialization of seedlings is based on the morphological characteristics of the plant, such as height, stem diameter, leaf color, and root development. Thus, initial protection and appropriate cultural treatments are necessary to ensure homogeneity, growth, and initial development, so that after transplanting the seedlings can withstand the adverse conditions found in the field, reducing the costs of replanting and cultural treatments (FERREIRA et al., 2007).

Horticultural species hold a poor nutrient use efficiency, thus being necessary high doses of fertilizers to achieve high yields (ZANDONADI et al., 2014). The use of biostimulants has increased worldwide as they derive from organic substances and there are various sources of natural compounds that act positively on plant development. Therefore, it is an alternative form of management that can replace the use of chemicals, resulting in a more sustainable method that can reduce costs in seedling production.

Biostimulants include products based on seaweed extract which, when applied, can act on the hormonal balance, and promote changes in the physiological and structural processes of plants (SILVA et al., 2008). Furthermore, the seaweed used for composting is both biodegradable and non-toxic and can be used by organic farmers. In Brazil, the biostimulant formulations are regulated under Normative Instruction No. 64, of December 18, 2008, from the Ministry of Agriculture, Livestock, and Food Supply (MAPA), in liquid and powder form (MAPA, 2008).

The *Ascophyllum nodosum* L. species belongs to the brown macroalgae group and is the most widely used in agriculture (UGARTE, SHARP, MOORE, 2006). They are known as natural biostimulants due to holding organic matter, amino acids (proline, isoleucine, glutamic acid, glycine, lysine, tryptophan), carbohydrates (starch, sucrose, raffinose), macro and micro nutrients, and growth hormones (auxins, gibberellins, cytokinins, and abscisic acid) that can be used in different crops and with different functionalities, such as: rooting agents, biostimulants, bioprotectors, and mitigators of adverse environmental conditions (SILVA, 2010).

A. nodosum extract offers versatile applications, such as foliar sprays and root immersion, and can also be added to irrigation and fertigation systems. The literature shows positive results when it is used in seed treatment, seedling production, and on plants already established in the field (NORRIE, 2008). Therefore, this study aimed to evaluate the effect of different doses of a seaweed-derived biostimulant, more specifically *Ascophyllum nodosum* L. extract, during the development of eggplant seedlings.

Material and methods

The experiment was conducted from September 14 to October 21, 2021, at the Horticulture Sector of the Federal Institute of Education, Science, and Technology of Southern Minas, Machado Campus (MG) (IFSULDEMINAS), Latitude 21° 41' 57.09" S and Longitude 45° 53' 11.01" W; 907 m above sea level.

The 'Classic F 1' eggplant seedlings were produced using commercial seeds, distributed in 200-cell plastic trays, duly filled with the commercial Max Fértil substrate (Figure 1A), with one seed inserted per cell. The trays were placed on metal benches in a Pad and Fan type greenhouse.

The experimental design adopted was randomized blocks, with five different doses (0, 3, 6, 9, 12 mL p c L^{-1}) of the *Ascophyllum nodosum* L. seaweed extract and 10 replicates, consisting of five plants per plot. The concentrations of the commercial product (Acadian®) were diluted in water and applied by root immersion, using recipients filled with one liter of syrup and immersing the pots individually in 22 L plastic boxes, measuring 15 × 36 × 56 cm, for three minutes in the solution (Figure 1B). The first application occurred 17 days after sowing and the second seven days after the first application.

Figure 1. Tray structure, root immersion of seedlings in solution, and variable sampling, considering the development of eggplant seedlings under different doses of biostimulant. A: trays used for sowing; B: application of Acadian® treatments; and C: cleaning the seedlings for evaluation. Machado (MG), 2021

After 34 days since sowing, the plants were removed from the pots and the roots washed in running water to completely remove the substrate (Figure 1C). After this process, the seedlings were subjected to morphological growth analyses: plant height—in cm, determined using a ruler, measuring the distance from the neck to the last leaf; root length—in cm, determined using a ruler, measuring the distance from the neck to the end of the root; stem diameter—in mm, determined using a digital caliper, positioned to measure the diameter of the mid-stem region, just below the first leaves; root dry mass and shoot dry mass—lastly, seedlings were placed in an oven with forced air circulation at 65° C for 48 h, after which their mass was determined using a digital semi-analytical balance.

The data obtained in the experiment were subjected to analysis of variance (ANOVA) at 5% probability. When the F test was significant, regression analysis was performed for the dose factor. All statistical analyses were performed using the Sisvar® statistical program (FERREIRA, 2010).

Results and discussion

According to the ANOVA results, there was a significant effect by the F test ($p<0.05$) for the characteristics evaluated under different doses of the biostimulant on the production of 'Classic F 1' hybrid eggplant seedlings. It was observed that plant height, root and shoot dry mass, and stem diameter, when subjected to regression analysis, developed a polynomial trend of degree 3, and root length had a polynomial trend of degree 2.

In this study, for the plant height variable (Figure 2), it was observed that, in the applications at doses of 3 and 6 mL L^{-1}, the highest means were found, with 16.31 and 15.42 cm, respectively, an increase of 4.01 and 3.29 cm compared with the treatment that was not treated. The value of the coefficient of determination (R^2) of 0.9589 indicates an adequate fit of the data to the polynomial equation obtained to estimate the ideal dose of 3.42 mL L^{-1}, which achieved a seedling height of 16.16 cm.

As for root length (Figure 3), positive behavior was observed from the first dose onwards, so that the highest means were obtained at doses of 9 and 12 mL L^{-1}, which recorded 9.44 and 9.25 cm—an increase of 1.89 and 1.70 cm compared to the zero dose. However, using the maximum point of the equation, the ideal dose of 6.78 mL L^{-1} was estimated, which achieved an average root length of 9.57 cm.

Amorim Neto (2019) obtained opposite results when using the biostimulant in the

Figure 2. Average values obtained for the variable plant height (in cm) according to different doses of the Acadian® biostimulant. Machado (MG), 2021. **F-test at 5% significance level.

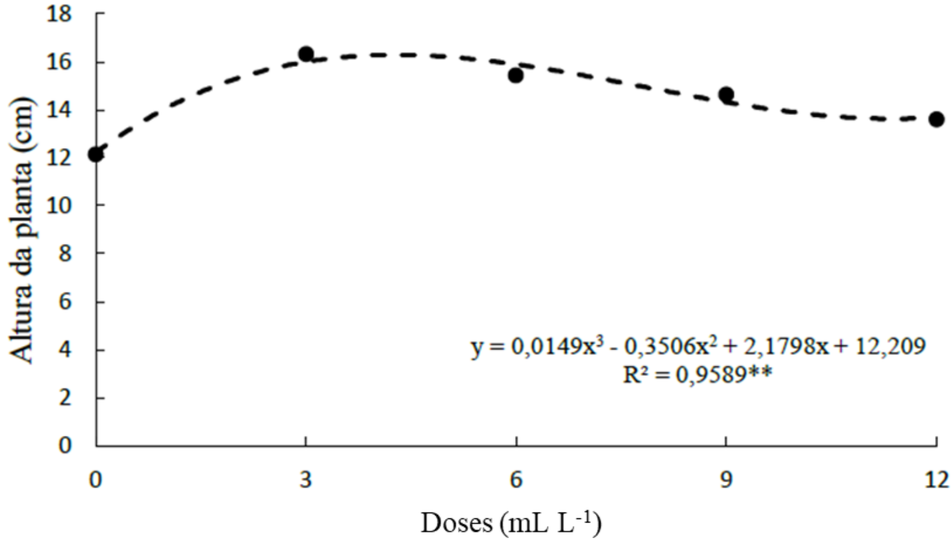
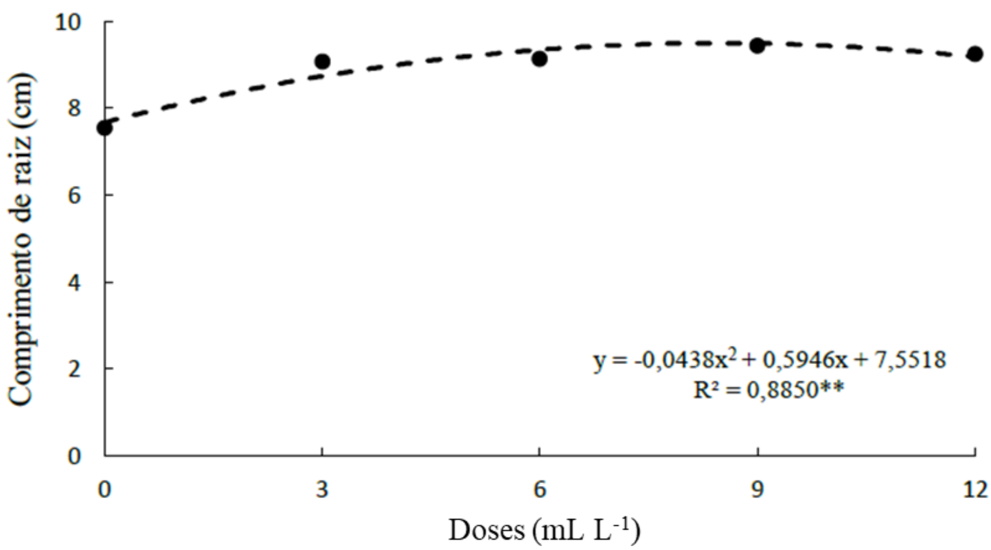


Figure 3. Average values obtained for the variable root length (in cm) according to different doses of the Acadian® biostimulant. Machado (MG), 2021. **F-test at 5% significance level.



production of tomato 'Salad Special' seedlings, recording an average 13.01 cm of shoot height at concentrations higher than 7 mL L^{-1}, and lower root development when doses higher than 2.5 mL L^{-1} were used. Results presented by Araújo et al. (2011) were similar to our data, showing an increase in the height of yellow passion fruit seedlings when the dose of 4 mL L^{-1} of the *Ascophyllum nodosum* L. extract was used.

The increase in root length may be associated with the use of seaweed extract. As evidenced by Rayorath et al. (2008), root development is induced by increased expression of genes pertinent to auxin, a hormone that acts as a growth regulator and participates in cell elongation; however, high doses of auxin can induce phytotoxicity (TAIZ, ZEIGER, 2009). Therefore, root length is relevant to acquire adequate seedling establishment after transplanting in the field, favoring soil fixation and root exploration.

The cytokinins found in the seaweed may explain the increase in plant height (KHAN et al., 2009). This hormone is synthesized by the roots and conducted by the xylem to the aerial part of the plant and provides greater plant development (SALISBURY, ROSS, 2012). Seaweed also present micronutrients and amino acids capable of inducing plant growth.

Commercial products derived from seaweed extract with higher concentrations of auxin are associated with lower concentrations of cytokinins and abscisic acid, which explains the increase in root growth and reduction in shoot development (WALLY et al., 2013). This variation occurs due to the difference between the species used, the time of collection, and the form of extraction, influencing the composition of the products and promoting different effects on the plants (CARVALHO, CASTRO, 2014).

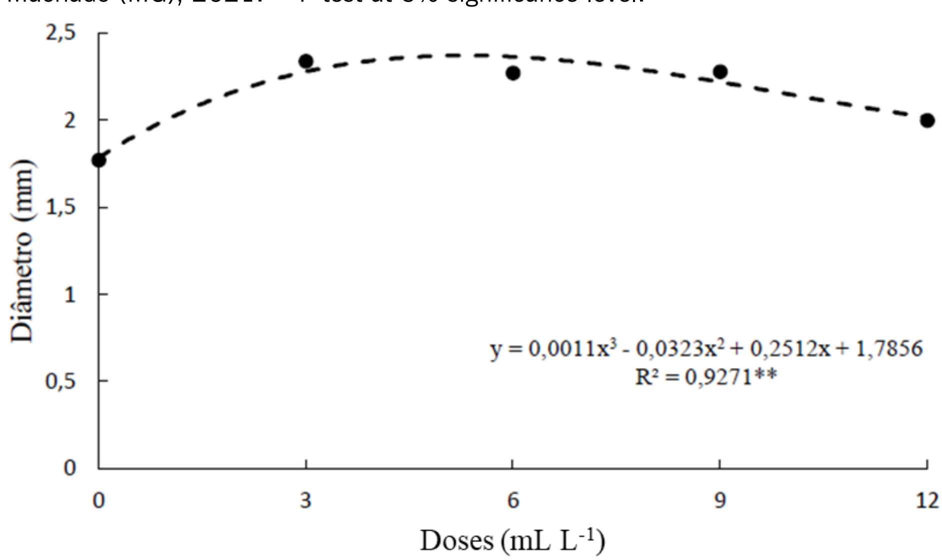
The reduction in shoot development may be caused by the high doses of biostimulants since higher concentrations of these products are only beneficial when used in unfavorable growing conditions (FERNANDES, SILVA, 2011).

Regarding stem diameter (Figure 4), a positive response was obtained, with the highest values associated to concentrations of 3 and 9 mL L^{-1}, ranging from 2.32 and 2.28 mm, meaning an increase of 0.57 and 0.51 mm compared to the zero dose. The ideal dose estimated by the equation was 5.33 mL L^{-1}, where the stem diameter reached values of 2.37 mm.

Santos *et al.* (2011) found that the application of Acadian® resulted in a positive response in stem diameter, with an average of 1.7 mm at the maximum concentration of 0.9 mL L^{-1} in IPA 6 tomato plants. On the other hand, Gonçalves *et al*. (2018) concluded that the application of the Stimulate® biostimulant to passion fruit cultivar 'BRS Rubi do Cerrado' reduced the plants' stem diameter.

This outcome may be associated with the presence of gibberellins, which synthesis is induced by the application of seaweed extract (TAIZ, ZEIGEIR, 2017). This hormone acts on the elongation of meristematic cells that, associated with auxins, provide greater elasticity and plasticity to cells, thus acting on cell division and, consequently, increasing stem diameter in plants (CELEDONIO, 2020; FERNANDES, SANTOS, RIBEIRO, 2001). Larger stem diameter can favor the transport of high amounts of nutrients and water to the shoot, providing growth and accumulation of biomass, in addition to acting on metabolic and photosynthetic processes (MAZZONI-VIVEIROS, TRUFEM, 2004).

Figure 4. Average values obtained for stem diameter (in cm) according to different doses of the Acadian® biostimulant. Machado (MG), 2021. **F-test at 5% significance level.



When applied in high doses, endogenous auxins promote root development and inhibit stem growth, an effect that may have been influenced by the application of seaweed extract (KERBAUY, 2012), which promoted a reduction in the growth of plant organs.

Regarding shoot dry mass (Figure 5) and root dry mass (Figure 6), a behavior similar to the other analyzed characteristics was observed, in which the highest values were reached with doses ranging from 3 to 6 mL L^{-1}, with averages of MSPA at 0.15 and 0.12 g, and MSR at 0.052 and 0.052 g. Optimally, a dose of 4.08 mL L^{-1} should be used for the dry mass of the shoot, which reached an average of 0.14 g; and a dose of 3.49 mL L^{-1} for the dry mass of the root, resulting in 0.052 g.

Vandruscolo, Martins, and Seleguini (2016) achieved very similar outcomes, in which concentrations lower than 5.5 ml L^{-1} yielded higher dry mass averages for tomato crops. Positive data were also obtained on the increase of dry matter in tomato seedlings using *Ascophyllum nodosum* extract *(SOUZA et al., 2017).* A value of 0.046 g of total dry matter was found using the maximum dose of 0.9 mL L^{-1}, thus encouraging the use of biofertilizer to produce seedlings.

Mógor et al. (2018) reported that the amino acids present in biostimulants can act on plant metabolism, as they contribute to protein synthesis. Therefore, according to the results found for these variables, the use of Acadian® promotes the best initial development of seedlings, possibly due to its growth hormones, which cause a synergistic effect and contribute to greater production and accumulation of carbohydrates and, consequently, greater production of dry matter (AL-ABBASI, ABDULLAH, and HUSSEIN, 2017).

Biostimulant positively influences root tissues and interfere with the hormonal balance of plants, providing greater exploration capacity and, consequently, greater absorption of water and nutrients, which are related to the metabolism and structuring of plant organs (NARDI et al., 2016).

Notably, high concentration doses caused a small reduction in the evaluated characteristics. Except for root length, this decrease may be associated with the stimulation of ethylene synthesis, caused by the excess of auxins in plant tissues (SALISBURY, ROSS, 2012). Consequently, the accumulation of ethylene can negatively influence cell growth and elongation.

Figure 5. Average values obtained for the variable shoot dry mass according to different doses of the Acadian® biostimulant. Machado (MG), 2021. **F-test at 5% significance level.

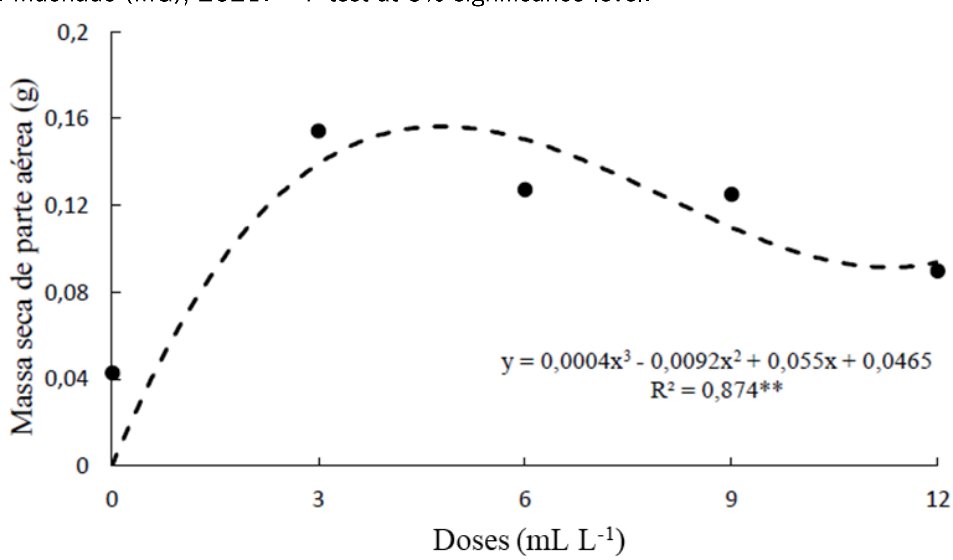
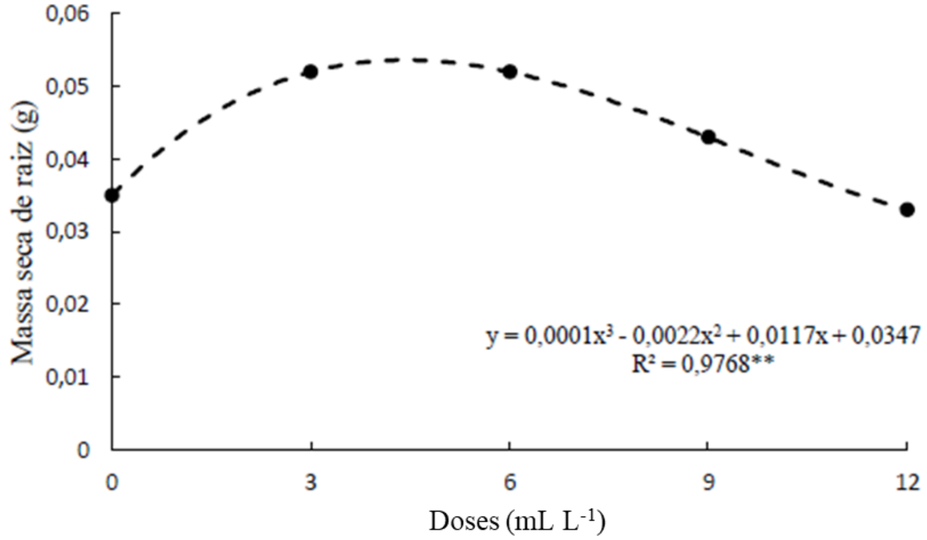


Figure 6. Average values obtained for the variable root dry mass, according to different doses of the Acadian® biostimulant. Machado (MG), 2021. **F-test at 5% significance level.



Another factor that may have influenced the research is that the study was conducted under controlled environmental conditions, and biostimulants have greater effects when used in stressful situations (POVERO et al., 2016)

Therefore, the seaweed extract *Ascophyllum nodosum* L. can be an important ally in the production of eggplant seedlings, showing its great potential to contribute to plant development, as well as being a natural source of nutrients, amino acids, and plant hormones. However, further studies should be conducted with lower doses associated with seed treatment and foliar spraying since there are variations in the composition of commercial products and plant species.

Conclusion

The use of *Ascophyllum nodosum-derived* biostimulant can increase the growth and development of plant height, root length, stem diameter, and root and shoot dry mass during the production phase of eggplant seedlings.

References

AL-ABBASI, G. B.; ABDULLAH, K. M.; HUSSEIN, Z. A. Effect of spraying with tecamin algae and NPK fertilizer on the growth of pomegranate (*Punica granatum* L.) seedlings cv. California wonderful. **IOP Conference Series: Earth and Environmental Science**, v. 388, n. 1, p. 12-22, 2017.

AMORIN NETO, A. F. **Produção de mudas de tomate com extrato de algas marinhas**. 29 f. Dissertação (Bacharel em Agronomia) – UniEvangélica, Centro Universitário de Anápolis, Anápolis-GO, 2019.

ARAÚJO, O.; GOES, G. B.; MELO, I. G. C.; DA COSTA, M. E.; DA SILVA, R. M. Uso do extrato de algas, *Ascophyllum nodosum*, na produção de mudas de maracujazeiro-amarelo. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, v. 6, n. 2, p. 1-4, 2011.

BHARATHI, P. V. L.; RAVISHANKAB, M. **Vegetable nursery and tomato seedling management guide for South and central India**. Local: Taiwan, 2018. Disponível em: <https://www.researchgate.net/profile/Ravishankar-Manickam/publication/324471192_VEGETABLE_NURSERY_AND_TOMATO_SEEDLING_MANAGEMENT_GUIDE_FOR_SOUTH_AND_CENTRAL_INDIA/links/5acebc21a6fdcc87840f26ea/VEGETABLE-NURSERY-AND-TOMATO-

SEEDLING-MANAGEMENT-GUIDE-FOR-SOUTH-AND-CENTRAL-INDIA.pdf> Acesso em: 20 out. 2023.

CAMPANHARO, M; RODRIGUES, J. J. V.; LIRA JÚNIOR; M. A.; ESPINDULA, M. C. Características físicas de diferentes substratos para produção de mudas de tomateiro. **Revista Caatinga**, v. 19, n. 2, p. 140-145, 2006.

CARVALHO, M. E. A.; CASTRO, P.R.C. Extratos de algas e suas aplicações na agricultura. **Série Produtor Rural**, v. 56, 58 p., 2014.

CELEDONIO, W. F. **Bioestimulante na produção de mudas de romãzeiras (*Punica granatum*) cv. Mollar**. 2020. 48f. Dissertação (Mestrado em Agricultura Tropical) – UFPB Campus II, Universidade Federal da Paraíba, Areia, 2020.

FERNANDES, A. L.; SILVA, R. O. Avaliação do extrato de algas (*Ascophyllum nodosum*) no desenvolvimento vegetativo e produtivo do cafeeiro irrigado por gotejamento e cultivado em condições de cerrado. **Enciclopédia Biosfera**, v. 7, n. 13, p. 147-157, 2011.

FERNANDES, M. do C. de A.; SANTOS, A. S.; RIBEIRO, R. L. D. Sensibilidade ao fungicida benomyl in vitro de isolados de *Colletotrichum gloeosporioides* provenientes de frutos de pimentão, jiló e berinjela. **Arquivos do Instituto Biológico,** v. 68, n. 2, p. 89-95, 2001.

FERREIRA, A. L.; OLIVEIRA, A. J.; VON PINHO, R. V. E.; QUEIROZ, D. L. Bioestimulante e fertilizante associados ao tratamento de sementes de milho. **Revista Brasileira de Sementes**, v. 29, n. 2, p. 80-89, 2007.

FERREIRA, D. F. SISVAR – **Sistema de análise de variância.** Versão 5.3. Lavras – MG: UFLA, 2010.

GONÇALVES, B. H. L.; SOUZA, J. M. A.; FERRAZ, R. A.; TECCHIO, M. A.; LEONEL, S. Efeito do bioestimulante Stimulate® no desenvolvimento de mudas de maracujazeiro cv. BRS Rubi do Cerrado. **Revista de Ciências Agrárias**, v. 41, n. 1, p. 147-155, 2018.

GUIMARÃES, V. F.; ECHER, M. M.; MINAMI, K. Métodos de produção de mudas, distribuição de matéria seca e produtividade de plantas beterraba. **Horticultura Brasileira**, v. 20, n. 3, p. 505-509, 2002.

KERBAUY, G.B. **Fisiologia vegetal**. Rio de Janeiro: Guanabara Koogan, 2012. 431p.

KHAN, W.; RAYIRATH, U. P.; SUBRAMANIAN, S.; JITHESH, M. N.; RAYORATH, P.; HODGES, D. M.; CRITCHLEY, A. T.; CRAIGIE, J.S.; NORRIE, J.; PRITHIVIRAJ, B. Seaweed extracts as biostimulants of plant growth and development. **Journal of Plant Growth Regulation**, v. 28, n. 1, p. 386-399, 2009.

MAPA, **Ministério da Agricultura Pecuária e Abastecimento**. Instrução Normativa nº 7, de 17 de maio de 1999. 2008. Disponível em: <http://www3.servicos.ms.gov.br/iagro_ged/pdf/489_GED.pdf>. Acesso em: 15 abr. 2023.

MAZZONI-VIVEIROS, S. C.; TRUFEM, S. F. B. Efeitos da poluição aérea e edáfica no sistema radicular de *Tibouchina pulchra* Cogn. (Melastomataceae) em área de mata Atlântica: associações micorrízicas e morfologia. **Brazilian Journal of Botany**, v. 27, n. 2, p. 337-348, 2004.

MÓGOR, Á. F.; ÖRDÖG, V.; LIMA, G. P. P.; MOLNÁR, Z.; MÓRGAR, G. Biostimulant properties of cyanobacterial hydrolysate related to polyamines. **Journal of Applied Phycology**, v. 30, n. 1, p. 453-460, 2018.

NARDI, S.; PIZZEGHELLO D.; SCHIAVONI, M.; ERTAI, A. Plant biostimulants: physiological responses induced by protein hydrolyzed-based products and humic substances in plant metabolism. **Scientia Agricola,** v. 73, n. 1, p. 28-23, 2016.

NORRIE, J. Advances in the use of *Ascophyllum nodosum* seaplant extracts for crop production: Linking laboratory and field research. In: FLUID FERTILIZER FOUNDATION FLUID FORUM, 2008, Scottsdale. **Anais...** Scottsdale: AZ, 2008. p. 1-6.

POVERO, G.; MEJIA, J. F.; TOMMASO, D.; PIAGGESI, A.; WARRIOR, P. A systematic approach to discover and characterize natural plant biostimulants. **Frontiers in Plant Science**, v. 7, n. 435, p. 1-9, 2016.

RAYORATH, P.; JITHESH, M. N.; FARID, A.; KHAN, W.; PALANISAMY, R., HANKINS, S. D., et al. Rapid bioassays to evaluate the plant growth promoting activity of *Ascophyllum nodosum* (L). Le Jol. using a model plant, *Arabidopsis thaliana* (L). Heynh. **Jounal of Applied Phycology,** v. 20, n. 4, p. 423–429, 2008.

SALLISBURY, F. B.; ROSS, C. W. **Fisiologia das plantas**. São Paulo: Cenguage Learning, 2012. 744p.

SANTOS, N. G. N.; PINTO, P.; SILVA, A. J.; MARQUES, R. S.; SANTOS, S. Eficiência de doses de fertilizante organomineral à base de extratos concentrados de algas marinhas na formação de mudas de tomate IPA-6 no município de Juazeiro-BA. In: CONGRESSO BRASILEIRO DE HORTICULTURA, 51., 2011, Viçosa. **Anais...** Viçosa: ABH, 2011. p. 4576-4580.

SILVA, C. G. F.; LASCHI, D.; ONO, E. O.; RODRIGUES, J. D.; MOGOR, A. F. Aplicação foliar do extrato de alga *Ascophyllum nodosum* e do ácido glutâmico no desenvolvimento inicial de crisântemos (*Dendranthema morifolium* (Ramat.) Kitam em vasos. **Revista Brasileira de Horticultura Ornamental**, v. 16, n. 2, p. 179-181, 2008.

SILVA, E. M. **Manejo da fertirrigação em ambiente protegido visando o controle da salinidade do solo para a cultura da Berinjela**. 77f. Tese (Mestrado em Irrigação e Drenagem), Universidade de São Paulo, Escola Superior de Agricultura “Luís de Queiroz”. Piracicaba – SP, 2010.

SOUZA, A. B.; PEREIRA, L. A. F.; SOUZA, J. V. G. A.; ALBUQUERQUE, J. R. T.; SOUZA, L. V.; BARROS JÚNIOR, A. P. Crescimento e desenvolvimento de mudas de tomate sob efeito de extrato *Ascophyllum nodosum*. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, v. 12, n. 4, p. 712-716, 2017.

TAIZ, L.; ZEIGER, E. **Fisiologia vegetal**. Porto Alegre: Artmed, 2009. 848p.

TAIZ, L.; ZEIGER, E.; MOLLER, I. M.; MURPHY, A. **Fisiologia e desenvolvimento vegetal**. Porto Alegre: Artmed, 2017. 858p.

UGARTE, R. A.; SHARP, G.; MOORE, B. Changes in the brown seaweed *Ascophyllum nodosum* (L.) Le Jol. plant morphology and biomass produced by cutter rake harvests in southern New Brunswick, Canada. **Journal of Applied Phycology**, v. 18, n. 3-5, p. 351-359, 2006.

VANDRUSCOLO, E. P.; MARTINS, A. P. B.; SELEGUINI, A. Promoção no desenvolvimento de mudas olerícolas com uso do bioestimulante. **Journal of Agronomic Sciences**, v. 5, n. 2, p. 73-84, 2016.

WALLY, O. S. D.; CRITCHLEY, A. T.; HILTZ, D.; CRAIGIE, J. S.; HAN, X.; ZAHARIA, L. I.;

ABRAMS, R. S.; PRITHIVIRAJ, B. Regulation of phytohormone biosynthesis and accumulation in Arabidopsis following treatment with commercial extract from the marine macroalga *Ascophyllum nodosum*. **Journal of Plant Growth Regulantion**. v. 32, n. 9, p. 324–339, 2013.

ZANDONADI, D. B.; SANTOS, P. M.; MEDICI, L. O.; SILVA, J. Ação da matéria orgânica e suas frações sobre a fisiologia de hortaliças. **Horticultura Brasileira**, v. 32, n. 1, p. 14-20, 2014.