2026 World Journal of Innovation and Modern Technology, Vol.9, Issue 5 (May)
ISSN 2682-5910
DOI: 10.53469/wjimt.2026.09(05).06

Biostimulant Potential of Seaweed Extracts in Onion Seed Treatment

Nkomba Kalobwe Fils*, Ilunga Kalenga Liliane Andre

Department of Science (Botany), OPJS University, Churu, Rajasthan, India
**Correspondence author, kalobwe98@gmail.com*

Abstract: ***Agriculture plays a fundamental role in the Brazilian economy, generating employment, wealth, and export revenues. The Irecê microregion in the state of Bahia is a notable center of agricultural production, particularly in onion cultivation, which contributes significantly to the local economy. However, onion crops face challenges such as diseases and pests, necessitating the adoption of modern management techniques. This study aimed to evaluate the impact of treating onion seeds with seaweed-based biostimulants on seed germination and early seedling development, comparing biostimulant-treated seeds with an untreated control group. The research also sought to provide producers with a scientific basis for achieving a more efficient and profitable production cycle. The variables analyzed included the Germination Speed Index (GSI), germination percentage (%G), fresh weight (FW), root system length (RSL), and shoot length (SL) across different biostimulant doses. The results demonstrated that the biostimulant positively influenced germination percentage and shoot length. Moreover, the use of the biostimulant did not increase the incidence of abnormal plants, thereby maintaining seedling quality. Consequently, seaweed-based biostimulants represent a valuable tool for improving the productivity and quality of onion crops while promoting more sustainable and environmentally responsible agricultural practices. Nevertheless, further studies are needed to optimize application concentrations and evaluate long-term impacts, thereby consolidating the use of such biostimulants in agriculture.***

Keywords: Biostimulant; Seaweed Extracts; Onion Seed.

1. INTRODUCTION

Agriculture in Brazil is known for its competitiveness and plays a fundamental role in generating employment, wealth, food, fibers, and bioenergy not only for domestic consumption but also for exports. The gross domestic product (GDP) of this sector represented 21% of the entire national economy, one-fifth of all jobs, and 43.2% of the country's exports in 2019 (EMBRAPA, 2020).

The Irecê microregion is located in the Brazilian Northeast, in the interior of the state of Bahia. This region is one of the most productive in Bahian agriculture; its economy is strongly based on agriculture and livestock. The city of Irecê has held important titles such as the Bean Capital and the World Castor Bean Capital, and currently stands out in the irrigation of carrots, onions, and other vegetables (Municipal Government of Irecê, 2017).

Onion production in this region is mainly destined for the domestic market, also supplying other regions of the country. Onion cultivation plays an important role in the local economy, providing income and employment for farmers and rural workers throughout the production cycle. Onion production in this territory generally follows conventional agronomic practices, including the appropriate selection of varieties, soil preparation, planting, cultural practices, pest and disease control, and harvesting (EMBRAPA, 2007).

However, the cultivation of this crop faces significant challenges, such as diseases, pests, and adverse weather conditions. These adversities favor the intensive use of synthetic fertilizers and pesticides, causing environmental damage and harm to public health. Thus, local producers need modern agricultural management techniques to maximize productivity, the quality of onion bulbs, and minimize environmental damage, such as the use of biostimulants for seed treatment (Carvalho; Castro, 2014).

The lack of consideration regarding seed treatment can result in the loss of the seeds' germinative potential and development. This technical gap can compromise the uniformity of crop establishment and, consequently, final productivity. During the onion germination stage, it is essential to ensure favorable conditions for the initial development of seedlings; in this context, the use of biostimulants, such as marine algae derivatives, becomes a technically and economically viable alternative (Carvalho; Castro, 2014).

By focusing specifically on the germination stage, the aim is not only to improve the germination rate of onion seeds but also to promote a more vigorous and uniform initial development of seedlings under adverse conditions, such as water and thermal stress. This technical improvement has direct implications for the quality and productivity of the onion crop, benefiting producers by ensuring a solid foundation for a more efficient and profitable production cycle. Thus, this work aims to analyze the impact of a marine algae extract biostimulant on onion seed treatment, focusing on seed germination and initial seedling development, with the goal of a more efficient and profitable production cycle.

2. THEORETICAL FRAMEWORK

2.1 Characterization of the Irecê Territory

The Irecê microregion is located in the Brazilian Northeast, in the interior of the state of Bahia, and is composed of 19 municipalities, with an area of 314 square kilometers. The climate of this region is semi-arid, covering the entire territory of the Polígono das Secas (Drought Polygon); rains are concentrated between November and January, while drought prevails in the remaining months. The average annual temperature is approximately 22°C, with significant seasonal variations (Municipal Government of Irecê, 2017).

This locality is one of the most productive in Bahian agriculture; its economy is strongly based on agriculture and livestock. The city of Irecê has held important titles such as the Bean Capital and the World Castor Bean Capital, and currently stands out in the irrigation of carrots, onions, and other vegetables (Municipal Government of Irecê, 2017).

2.2 Onion Crop

Onion production in this region is primarily intended for the domestic market, also supplying other regions of the country. The onion crop plays an important role in the local economy, providing income and employment for farmers and rural workers throughout the production cycle. Onion production in this territory generally follows conventional agronomic practices, including the appropriate selection of varieties, soil preparation, planting, cultural practices, pest and disease control, and harvesting (EMBRAPA, 2007).

However, the cultivation of this crop faces significant challenges, such as diseases, pests, and adverse weather conditions. These adversities favor the intensive use of synthetic fertilizers and pesticides, causing environmental damage and harm to public health. Thus, local producers need modern agricultural management techniques to maximize productivity, the quality of onion bulbs, and minimize environmental damage, such as the use of biostimulants for seed treatment (Carvalho; Castro, 2014).

The lack of consideration regarding seed treatment can result in the loss of seed germination potential and development. This technical gap can compromise the uniformity of crop establishment and, consequently, final productivity. During the onion germination stage, it is crucial to ensure favorable conditions for the initial development of seedlings; in this context, the use of biostimulants, such as marine algae derivatives, becomes a technically and economically viable alternative (Carvalho; Castro, 2014).

2.3 Marine Algae Used in Onion Seed Treatment

Products derived from algae extracts, especially those from marine species, represent a rich source of essential bioactive compounds for plant growth and development. The organic matrix of these extracts is complex and includes essential nutrients, amino acids, oligosaccharides, and various plant hormones, including cytokinins, auxins, abscisic acid, gibberellins, betaines, and alginates. Studies have shown that the application of these extracts can significantly increase the germination and vigor of seedlings of various species, providing robust and healthy initial growth (Carvalho; Castro, 2014).

Among marine algae extracts, Ascophyllum nodosum stands out, widely studied for its plant growth-promoting properties and its applicability in both human and animal nutrition. The application of commercial Ascophyllum nodosum extract has been shown to be decisive in promoting barley seed germination, stimulating gibberellin-independent amylase activity, essential for converting starch into sugars and, consequently, for the development of the embryonic axis. Furthermore, studies have also shown an increase in the germination percentage of Vigna radiata seeds after treatment with extracts from different marine algae species, such as Sargassum plagiophyllum, Turbinaria conoides, Padina tetrastromatica, Dictyota dichotama, and Caulerpa scalpelliformis. These results indicate that specific doses of these agrochemicals, generally ranging from 0,3% to 0,5% , can result in a significant improvement in seed germination, providing a germination rate of 80% to 100%, compared to only 70% observed in untreated seeds, highlighting the effectiveness of the extracts in seed treatment (Carvalho; Castro, 2014).

These findings highlight the effectiveness of marine algae extracts in seed treatment, demonstrating their potential to optimize the initial establishment of crops, thereby increasing productivity and crop quality, including onion crops. By promoting vigorous initial growth, algae extracts can significantly improve crop viability, becoming an essential tool for modern and sustainable agricultural practices (Carvalho; Castro, 2014).

The main marine algae extracts used for seed treatment are Ascophyllum nodosum, Kappaphycus alvarezii, Ecklonia maxima, and Sargassum sp., described below.

2.3.1 Ascophyllum Nodosum

Ascophyllum nodosum, a marine alga commonly found in North Atlantic regions, has been extensively studied for its beneficial properties in agriculture. Craigie (2011) highlights that extracts of this alga are rich in plant hormones, primarily auxins, which are known to promote root growth and plant development. The presence of unique polysaccharides, such as laminarin and alginic acid, also contributes to improving plants' ability to absorb nutrients and water from the soil. Studies by Khan et al. (2009) reinforce this perspective, showing a significant increase in photosynthetic efficiency and resistance to abiotic stress in plants treated with A. nodosum extracts. Additionally, regular application of this extract can result in more robust and resilient plants, capable of withstanding adverse conditions more effectively.

2.3.2 Kappaphycus Alvarezii

Kappaphycus alvarezii, often cultivated in tropical regions, is notable for its richness in nutrients and bioactive compounds. Hayashi and Reis (2012) investigated this alga and found that it contains high levels of potassium and calcium, essential for healthy plant development. Furthermore, the alga has gelling properties that help retain water in the soil, a crucial factor for onion growth, especially in water-scarce regions or drought conditions. The water retention promoted by Kappaphycus alvarezii can significantly increase water use efficiency, making plants more resistant to dry periods.

2.3.3 Ecklonia Maxima

Ecklonia maxima, found along South African coasts, is known for its high content of natural auxins and alginic acid. Khan et al. (2006) showed that E. maxima extracts stimulate plant growth and cell differentiation. Additionally, the presence of phenolic compounds and antioxidants contributes to protecting plants against pathogens and environmental stresses, which can be particularly beneficial for onion cultivation, often susceptible to fungal and bacterial diseases. The application of E. maxima can enhance plant resistance to a variety of stresses, resulting in healthier and more productive crops.

2.3.4 Sargassum Sp.

Sargassum sp., an alga found in various oceanic regions, has been studied for its unique properties as a biostimulant. Zodape et al. (2011) observed that extracts of this alga significantly improve crop quality and yield. The alga is rich in trace elements and essential nutrients, such as nitrogen, phosphorus, and potassium, which are vital for healthy plant growth. Moreover, the presence of compounds like phytohormones and amino acids promotes overall plant health and resistance. The use of Sargassum sp. can result in more vigorous plants with a greater ability to face environmental challenges, contributing to more sustainable agricultural production.

2.4 Implications for Onion Seed Treatment

The application of these seaweed extracts in onion seed treatment can provide various benefits, such as promoting initial growth, strengthening roots, improving nutrient absorption, and enhancing resistance to environmental stress. Promoting initial growth and strengthening roots can result in a better germination rate and seedling establishment. Additionally, improved nutrient absorption and resistance to environmental stress can lead to increased onion productivity and quality. These benefits are particularly relevant in the context of sustainable agricultural practices, where reducing chemical use and increasing resource efficiency are fundamental. The use of marine algae extracts in onion seed treatment not only improves crop yield and quality but also contributes to long-term agricultural sustainability (Carvalho; Castro, 2014).

3. METHODOLOGY

The experiment was conducted in the multidisciplinary laboratory of the Faculdade de Irecê (FAI), located on the Irecê campus - BA.

The trial involving onion cultivation (cultivar TPX-30435) was conducted using a completely randomized experimental design in a factorial scheme 1x5 (crop x dose), with four replications. The treatments consisted of using variable doses (0.00; 0,5;2,0;3,5;5,0mL/kg per seed) in onion cultivation.

Figure 1: product dilution and seed treatment

The biostimulant used for seed treatment is a mixed mineral fertilizer extracted from 4 different species of marine algae: A. nodosum, K. alvarezii, E. maxima, and Sargassum sp. It has a density of 1.05 g/mL and an electrical conductivity at 25℃ of 0,31mS/cm. It is composed of Nitrogen (N) 1.0% w/w (10.5 g/L w/v), Boron (B) 0.015% w/w (0.157 g/L w/v), raw materials: urea/boric acid/water, and complexing agents [90% concentrated active marine algae (Ascophyllum Nodosum (48%), Kappaphycus Alvarezi (22%), Ecklonia maxima (15%), Sargassum sp. (15%))].

To prepare the treatments, the seaweed product was diluted in a 1:9 ratio, where each 9 mL of water received 1 mL of the product. 20g of seeds were used for each treatment, to which the dilution was applied according to the stipulated dosages, as shown in Figure 1. The seeds were subsequently shade-dried, then 50 seeds were randomly collected from each of the 5 treatments to perform the experimental procedure.

Sowing of the seeds was carried out on Germitest paper, the paper was moistened with 2.5 mL of distilled water, and the seeds were distributed in rolls, as shown in Figure 2. The seeds were then taken to the germination chamber, maintained at a temperature of 20℃ with a 24-hour photoperiod.

Figure 2: sowing of seeds on paper Germitest.

The variables analyzed include the germination speed index (GSI), calculated by the following equation:

$$\text{IVG} = \sum(ni/ti) \quad (1)$$

Where:
ni represents the number of seeds germinated at time 'i'
ti represents the time after the test was set up.

Data collection for the IVG was carried out from 2° to 10° days after the experiment was set up. The first germination count indicates seed vigor, while the sum of the results from the first count and the last count indicates their viability.

Figure 3: Determination of fresh mass.

Determination of fresh mass (FM) was performed after data collection for the IVG. The seedlings were weighed on an analytical balance to obtain the FM, as shown in Figure 3.

The shoot length (SL) and root system length (RSL) of the seedlings were determined using a graduated ruler.

Normal seedlings (NS) and abnormal seedlings (AS) were counted 10 days after the experiments were set up. Abnormal seedlings are those that do not have the potential to continue their development and produce normal plants, as defined by the Rules for Seed Analysis (RAS, 2009).

The data were subjected to analysis of variance using the F-test, followed by mean comparisons using the Scott-Knott test, with a significance level of 5%. Statistical analyses were conducted using Sisvar software.

4. RESULTS AND DISCUSSIONS

From the data obtained in the germination test of onion seeds treated with biostimulant, it is noted that there were significant responses for the analyzed variables.

For hypocotyl length, the highest value was found at the 5.0 mL/L dose (55.13mm), making this dose superior to the others tested, while the control (0ml/L) had a value of 41,81mm, the lowest among all. However, for radicle length, the 2.0 mL/L dose stood out over the other treatments with 29.28mm, and the 5.0 mL/L dose showed the second highest length of the organ in question, 29.17mm. The fresh mass data revealed that with the exception of the 2.0 mL/L dose (0.026g), all treatments did not differ significantly from each other, with mean values ranging from 0.029 to 0.032g (Table 1).

Table 1: Mean values for shoot length (SL), root system length (RSL), and fresh matter (FM) obtained from the initial development assay of the onion crop subjected to doses of algae extract.

Doses (ml/L)	CPA (mm)	CSR (mm)	MF (g)
0,0	41,83 e	26,20 e	0,030 a
0,5	49,03 c	27,68 c	0,029 a
2,0	45,93 d	29,28 a	0,026 b
3,5	52,03 b	27,22 d	0,032 a
5,0	55,13 a	29,17 b	0,030 a
CV(%)	3,71	0,22	3,27
Mean	48,79	27,91	0,030

Media followed by the same lowercase letter in the column belong to the same grouping by the Scott-Knott Criterion at the 5% probability level by the F test. CV (%): coefficient of variation.
Source: Prepared by the Author, 2024.

As can be observed in Table 2, the germination percentage data show that the 5.0 mL/L dose presented the best responses compared to the other doses, with 91% of seeds germinated. For the germination speed index, the 0.5; 2.0 and 5.0 ml/L doses showed no significant difference, with an average GSI between 17.76 and 17.96. However, the 3.5 ml/L dose showed the highest GSI at 18.47. In contrast, for the mean germination time, the 3.5 ml/L dose had the shortest time at 6 days, while the 5.0 ml/L dose had the longest time, with an average of 9 days required for the majority of seeds to germinate in the treatment.

Table 2: Mean values for germination percentage (%G), germination speed index, and mean germination time (MGT) obtained from the initial development test of the onion crop subjected to seaweed extract doses.

Doses (ml/L)	% G	IVG	TMG (days)
0,0	89,50 b	17,14 c	7,50 b
0,5	82,50 d	17,94 b	7,75 b
2,0	86,00 c	17,76 b	7,50 b
3,5	89,00 b	18,47 a	6,00 c
5,0	91,00 a	17,86 b	9,00 a
CV(%)	1,02	0,53	4,87
Mean	87,60	17,83	7,55

Media followed by the same lowercase letter in the column belong to the same grouping by the Scott-Knott Criterion at the 5% probability level by the F-test. CV (%): coefficient of variation.
Source: Prepared by the Author, 2024.

The results in Table 3 indicate that the seaweed-based biostimulant had a significant impact on the number of abnormal or normal plants for the treatments, such that the 2.0 ml/L dose had the highest number of abnormal plants (17.25 plants), while the 3.5 ml/L dose had the highest number of normal plants and the lowest number of abnormal plants among the treatments, 39.25 and 11.00 plants, respectively.

Table 3: Mean values for normal plants (PN) and abnormal plants (PA) obtained from the initial development trial of the onion crop subjected to doses of seaweed extract.

Doses (ml/L)	PN	PA
0	37,00 b	14,00 b
0,5	36,75 b	13,25 b
2	37,00 b	17,25 a

3,5	39,25 a	11,00 d
5	37,75 b	12,25 c
CV(%)	2,42	3,60
Mean	37,55	13,55

Media followed by the same lowercase letter in the column belong to the same grouping by the Scott-Knott Criterion at the 5% probability level using the F-test. CV (%): coefficient of variation
Source: Prepared by the Author, 2024.

Figure 4 shows the root system length (mm) as a function of the interaction of algal stimulant doses (mL/L). A positive trend is observed in the graph, where root system length increases slightly with increasing bio stimulant doses. The regression line equation (y=0,3739x+27,083) indicates that for each additional unit of bio stimulant dose, the RSL increases by approximately 0,3739mm. Coefficient of Determination (R^2): The coefficient of determination (R^2 = 0.3503) suggests that about 35.03% of the variation in root system length can be explained by the variation in bio stimulant doses. Although this value is not very high, it indicates a moderate relationship between the variables. The results obtained indicate that the marine algae-based bio stimulant may have a positive, albeit modest, effect on the root system length of onion seedlings. This observation is consistent with previous studies that demonstrate the benefits of algae extracts on root growth. Bioactive components present in algae, such as auxins and gibberellins, are known to promote cell division and elongation, which may contribute to increased root length. However, the relatively low coefficient of determination suggests that the impact of the bio stimulant is not the only determining factor of root growth. Environmental conditions, seed quality, and agricultural management practices also play crucial roles in seedling development. Therefore, while the bio stimulant can be a useful tool to improve root growth, it should be part of an integrated set of agricultural practices to optimize results.

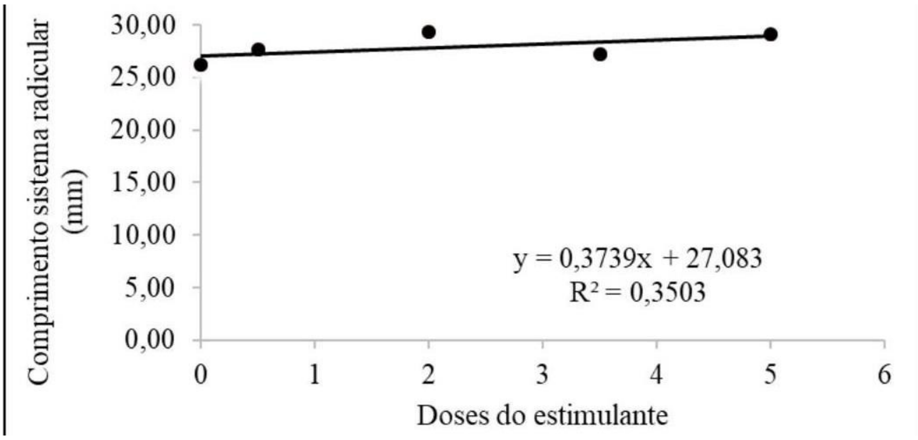

Figure 4: Root system length (mm) as a function of the interaction of algal stimulant doses (mL/L).

Figure 5 shows a clear positive trend, where shoot length increases with increasing bio stimulant doses. The regression line equation (y = 2.1651x + 44.005) indicates that for each additional unit of bio stimulant dose, the SL increases by approximately 2.1651 mm. The coefficient of determination (R^2=0,7553) suggests that approximately 75.53% of the variation in shoot length can be explained by the variation in bio stimulant doses. This relatively high value indicates a strong relationship between the variables. The results obtained indicate that the marine algae-based bio stimulant has a significant positive effect on the shoot length of onion seedlings. The strong correlation observed between bio stimulant doses and increased shoot length suggests that the bioactive components of algae effectively promote vegetative growth. Previous studies, such as those by Khan et al. (2009), have also shown that algae extracts can significantly increase vegetative growth in various crops, supporting the results observed in this study. The presence of auxins and gibberellins in algae extracts is crucial for cell elongation and cell division, fundamental processes for shoot growth. Additionally, the nutrients and amino acids present in algae improve seedling nutrition, providing the necessary elements for robust growth.

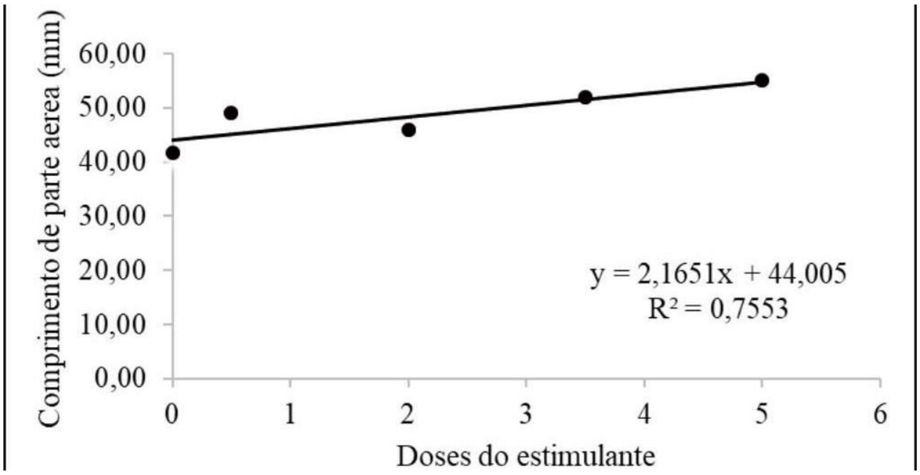

Figure 5: Aerial part length (mm) as a function of the interaction of algal stimulant doses (mL/L).

Figure 6 indicates a slightly positive trend, where the IVG increases marginally with increasing bio stimulant doses. The regression line equation (y = 0.1317x + 17.542) suggests that for each additional unit of bio stimulant dose, the IVG increases by approximately 0.1317. The coefficient of determination (R^2=0,3327) indicates that about 33.27% of the variation in IVG can be explained by the variation in bio stimulant doses. This value is not very high, suggesting that there are other factors besides the bio stimulant dose that influence germination speed. The results indicate that the marine algae-based bio stimulant has a very limited effect on the Germination Speed Index of onion seeds. The marginal impact can be attributed to the complexity of the physiological processes involved in germination, which are influenced by a variety of factors beyond bio stimulant treatment. Previous studies have also shown that while bio stimulants can improve certain plant growth characteristics, their impact on germination speed may be less pronounced. The bioactive components present in algae, such as auxins, gibberellins, and amino acids, can enhance germination, but their effectiveness may vary depending on the specific conditions of each experiment.

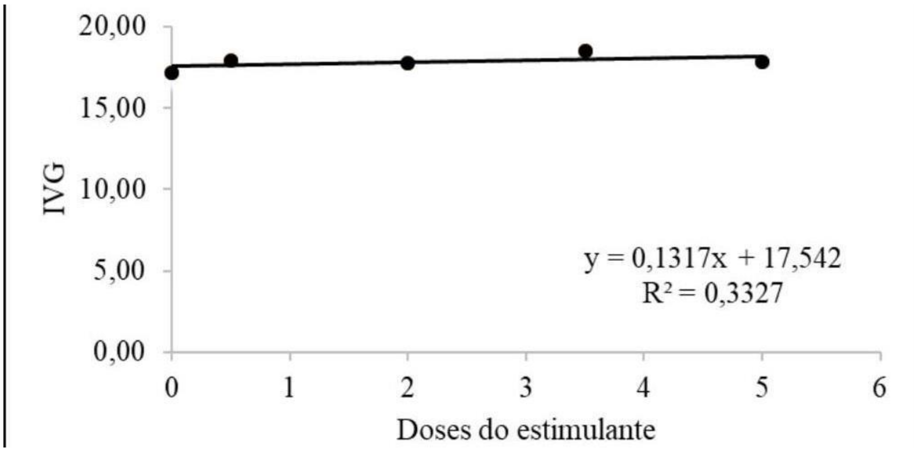

Figure 6: Germination Speed Index - GSI as a function of the interaction of algal stimulant doses (mL/L).

Figure 7 shows a slight positive trend, where the germination percentage increases with increasing bio stimulant doses. The regression line equation (y = 0.9335x + 85.546) suggests that for each additional unit of bio stimulant dose, the germination percentage increases by approximately 0.9335%. The coefficient of determination (R2 = 0.3299) indicates that approximately 32.99% of the variation in germination percentage can be explained by the variation in bio stimulant doses. This value is not very high, suggesting that other factors besides the bio stimulant dose influence germination. The results indicate that the marine algae-based bio stimulant has a positive, albeit slight, effect on the germination percentage of onion seeds. Bioactive components such as phytohormones, amino acids, and minerals present in algae extracts are known to promote physiological processes that can improve germination. Previous studies, such as those by Zodape et al. (2011), have shown that algae extracts can improve plant germination and vigor, corroborating the results observed in this study.

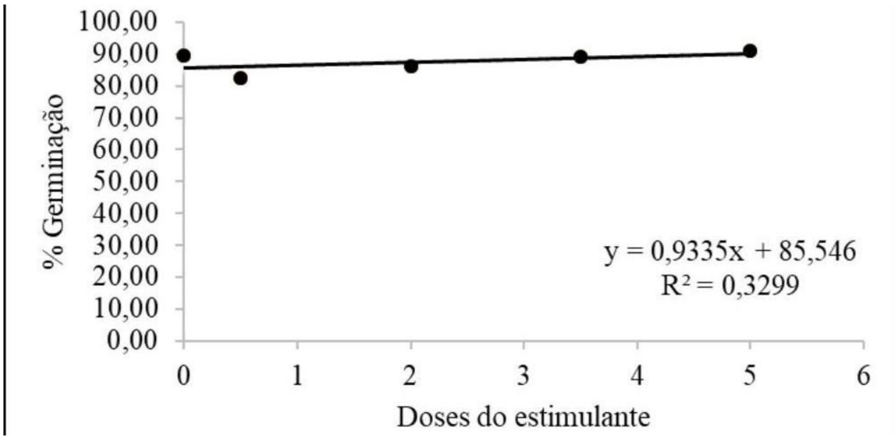

Figure 7: Germination percentage (%) as a function of the interaction of algal stimulant doses (mL/L).

Figure 8 shows a slight positive trend, where fresh mass increases slightly with increasing doses of the biostimulant. The regression line equation (y = 0.0006x + 0.0282) suggests that for each additional unit of biostimulant dose, fresh mass increases by approximately 0.0006 g. The coefficient of determination (R^2=0,2598) indicates that about 25.98% of the variation in fresh mass can be explained by the variation in biostimulant doses. This value is not very high, suggesting that factors other than biostimulant dose significantly influence seedling fresh mass. The results indicate that the marine algae-based biostimulant has a positive, albeit modest, effect on the fresh mass of onion seedlings. Bioactive components such as phytohormones, amino acids, and minerals present in algae extracts are known to promote plant growth and biomass accumulation. Previous studies, such as those by Craigie (2011), have shown that algae extracts can improve plant growth and vigor, supporting the results observed in this study.

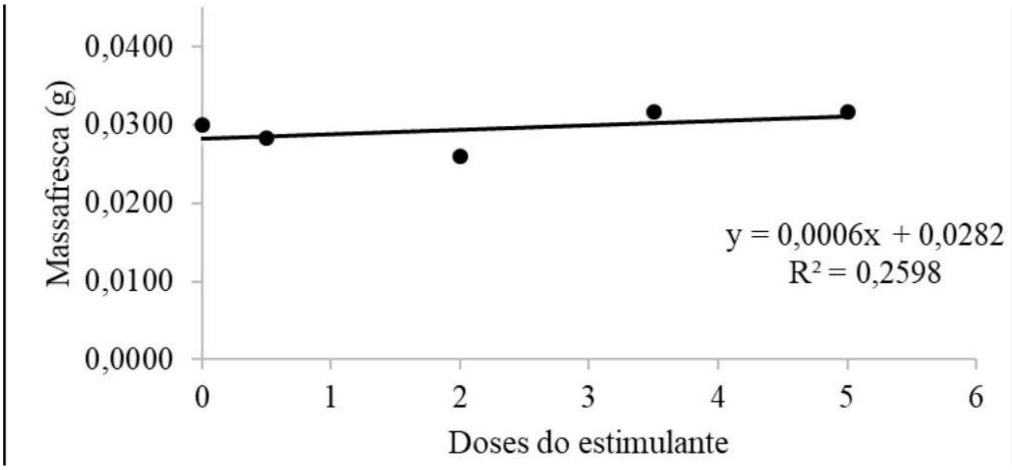

Figure 8: Fresh mass (g) as a function of the interaction of the stimulant doses (mL/L) of algae.

Figure 9 shows a slight positive trend, where the number of normal plants increases slightly with increasing doses of the biostimulant. The regression line equation (y=0,315x+36,857) suggests that for each additional unit of biostimulant dose, the number of normal plants increases by approximately 0.315. The coefficient of determination (R^2=0,4112) indicates that approximately 41.12% of the variation in the number of normal plants can be explained by the variation in biostimulant doses. This value is moderate, suggesting that factors other than biostimulant dose also significantly influence the number of normal plants. The results indicate that the marine algae-based biostimulant has a positive, albeit slight, effect on the number of normal onion seedlings. Bioactive components such as phytohormones, amino acids, and minerals present in algae extracts are known to promote healthy plant development. Previous studies, such as those by Zodape et al. (2011), have shown that algae extracts can improve plant health and vigor, supporting the results observed in this study.

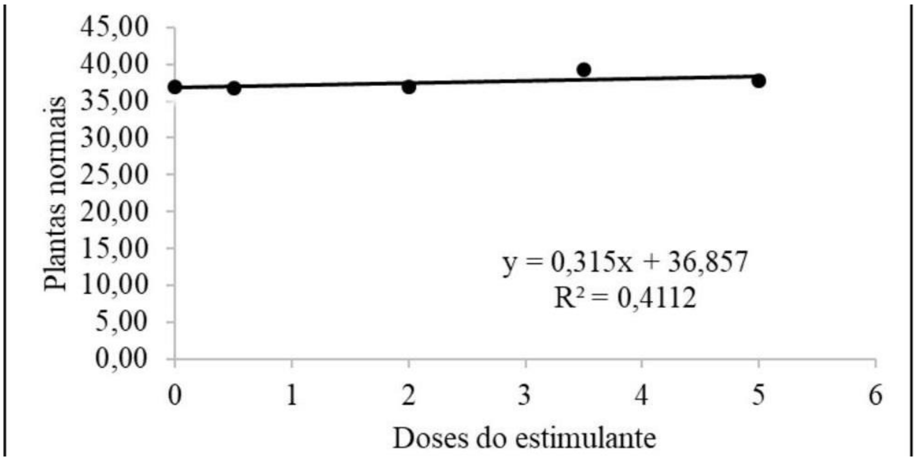

Figure 9: Normal plants (quantity) as a function of the interaction of algae stimulant doses (mL/L).

The results indicate that marine algae-based biostimulants can contribute significantly to more efficient and productive agricultural practices, improving the quality of onion crops. However, the variability in observed responses suggests that more research is needed to determine the ideal conditions of use and the most effective concentrations for different cultivation conditions.

5. CONCLUSION

It is concluded that agriculture plays an essential role in the economy, with the onion crop being particularly relevant to the Irecê microregion, generating employment and income. The use of marine algae-based biostimulants has proven promising, promoting significant improvements in the germination and growth of onion seedlings without negatively affecting plant development. Thus, the adoption of biostimulants emerges as a modern and effective technique to increase crop productivity and quality, contributing to more sustainable agricultural practices.

ACKNOWLEDGMENTS

The completion of this Course Completion Work would not have been possible without the support and collaboration of many people to whom I am deeply grateful. First, I thank God for the strength and wisdom granted throughout this academic journey. To my family, for their unconditional love, constant encouragement, and support at all times. You are the foundation of everything.

I thank my advisor, Prof. Msc. Lucas Barbosa dos Santos, for his guidance, patience, and valuable contributions throughout the entire process. His expertise and dedication were fundamental to the development of this work. To Faculdade Irecê, for providing a stimulating academic environment and the resources made available during my training. To the professors of the Agronomy Engineering course, for the teachings and knowledge sharing that were essential to my training. To my course colleagues, for the exchange of experiences, support, and friendship over these years. Together, we faced challenges and celebrated achievements.

And finally, to all who directly or indirectly contributed to the completion of this work, I express my sincere gratitude here.

REFERENCES

[1] CARVALHO, M. E. A.; CASTRO, P. R. C. Extratos de algas e suas aplicações na agricultura. Piracicaba: ESALQ - Divisão de Biblioteca, 2014. ISSN 1414-4530.

[2] CRAIGIE, J. S. Seaweed extract stimuli in plant science and agriculture. J Appl Phycol, 2011, 23:371-393. DOI 10.1007/s10811-010-9560-4. Available at: <https://link.springer.com/article/10.1007/s10811-010-9560-4>, accessed on: January 9, 2024.

[3] EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária Ministério da Agricultura, Pecuária e Abastecimento. VII Plano Diretor da Embrapa: 2020-2030. Brasília, DF: Embrapa, 2020.

[4] EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária Ministério da Agricultura, Pecuária e Abastecimento. Cultivo da Cebola no Nordeste. (Embrapa Semi-Árido. Sistemas de Produção). ISSN 1807-0027. Petrolina: Embrapa Semi-Árido, 2007.

[5] HAYASHI, L.; REIS, R. P. Cultivation of the red algae Kappaphycus alvarezii in Brazil and its pharmacological potential. Revista Brasileira de Farmacognosia. v. 22, n. 4, p. 748-752, 2012.

[6] 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.

[7] Seaweed Extracts as Biostimulants of Plant Growth and Development. J Plant Growth Regul, 2009. DOI 10.1007/s00344-009-9103-x. Available at: <https://www.researchgate.net/publication/236231425_ Seaweed_Extracts_as_Biostimulants_of _Plant_Growth_and_Development#read>, accessed on: January 9, 2024.

[8] PREFEITURA MUNICIPAL DE IRECÉ. Dados Geográficos. Author: Jackson Rubem, 2017. Available at: http://www.pmirece.ba.ipmbrasil.org.br/artigo?codartigo=192#:~:text=A%20microrregi%C3%A3o%20de %20Irec%C3%AA%20%C3%A9, Gabriel%2C%20Souto%20Soares%2C%20Uiba %C3%AD, accessed on: March 23, 2024.

[9] ZODAPE, S. T.; GUPTA, A.; BHANDARI, S. C.; RAWAT, U. S.; CHAUDHARY, D. R.; ESWARAN, K.; CHIKARA J. Foliar application of seaweed sap as biostimulant for enhancement of yield and quality of tomato (Lycopersicon esculentum Mill.). Journal of scientific & industrial research, v. 70, p. 215-219, 2011.