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**ANALYSIS OF THE INFLUENCE OF MICROALGAE AS  
BIOFERTILIZERS AND INTEGRATION INTO THE RENEWABLE  
ENERGY SYSTEM**

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**Abstract.** The use of biofertilizers that promote plant growth, based on microalgae and rhizobacteria, have been increasingly adopted as an alternative to increase agricultural production and reduce dependence on chemical fertilizers. These biostimulants are able to improve plant growth due to their high levels of essential nutrients such as nitrogen, phosphorus and potassium, also increasing resistance to disease and environmental stress. The ease of cultivation of these microorganisms in the laboratory makes their production scalable and efficient and, in addition, by using microalgae and rhizobacteria as biostimulants, it is possible to reduce the use of chemical fertilizers and pesticides, which benefits both the environment and human health. , and may also contribute to increasing plant productivity and improving the quality of food produced. In addition, it is possible to reduce dependence on chemical fertilizers and generate economic benefits in the pharmaceutical and cosmetic industry. In order to guarantee the viability and sustainability of microalgal biomass production, it is important to constantly monitor the physical and economic performance of the system. It is possible to explore the full potential of microalgae as a source of plant biofertilizers and metabolites of biotechnological interest. In addition to the benefits for agricultural production and industry, the production of microalgal biomass may be associated with the use of renewable energy sources. Photobioreactor systems use sunlight as an energy source for the photosynthesis process and, therefore, can be used to produce biomass. In addition, residual biomass can be used as an energy source in anaerobic digestion systems, generating biogas and promoting the generation of renewable energy. The production of microalgal biomass as a plant biostimulant and source of metabolites of biotechnological interest can be integrated into renewable energy systems, contributing to sustainable development and reducing dependence on fossil energy sources. Thus, the present work aims to evaluate and compare the effects of different biostimulants that promote plant growth, belonging to the inoculant Pastomax (BIOTROP, Vinhedo, SP., Brazil), using solutions made alone and in association with the microalgae *Tetradesmus obliquus* and the rhizobacteria *Azospirillum brasilense* and *Pseudomonas fluorescens*, respectively. The study was conducted in a completely randomized experimental design, with three replications. The treatments were subsequently followed by analysis of chlorophyll content, leaf growth and root growth, aiming to understand the behavior of microalgae and bacteria when used as plant biostimulants.

**Keywords:** Renewable sources; microalgae; metabolites; biofertilizer; sustainable chain

## 1. INTRODUCTION

Microorganisms are fundamental constituents and represent a large part of the living soil biomass, they play a key role in biogeochemical cycles and have great potential for use in agriculture and environmental protection (Singh et al., 2017). Despite the large investments made in scientific research in order to understand its effects and improve plant growth, its current use is still low. Microbial inoculants are an emerging technology that aims to increase the productivity of agricultural and agroecological systems in the long term. They are considered a more sustainable option compared to the increasing use of agrochemicals and fertilizers (Kawalekar, 2013). Most of these microorganisms are capable of establishing a symbiotic relationship with plants, promoting root growth, increased biomass and commercial yield (Conti et al., 2012). These microorganisms are known as Plant Growth Promoting Rhizobacteria (PGPR).

Among PGPR bacteria, the main bacteria of this group are *Pseudomonas spp.* and *Azospirillum spp.* that are addressed in this study, in addition to several other gram-positive bacteria. There are few studies on how PGPR bacteria interact with each other, except for some tests that used mixtures with two biocontrol agents or two biofertilizers (Costa, 2012). Field trials using these blends resulted in increased productivity and disease resistance in plants compared to using individual strains. However, not much is known about how much each strain contributes to overall crop performance (Atkinson & Watson, 2000). Aiming to upgrade these bacteria productivity, they can be combined with microalgae, which are also known as plant growth promoters (Furlan et al., 2020).

Microalgae are unicellular photosynthetic organisms that can grow in a wide variety of environmental conditions (Pereira et al., 2012), as shown in Figure 1. As primary productions, they use photosynthesis to absorb solar energy and atmospheric carbon dioxide to produce biomass (Bertoldi et al., 2008). The species of microalgae *Tetradesmus obliquus* is known for its bioactive properties, such as antimicrobial, anticancer, antioxidant and healing activity, which has become relevant for the industry.



Figure 1. Culture of microalgae at NPDEAS, UFPR.

*T. obliquus* is highly adaptable to different environments and has the ability to accumulate large amounts of lipids in its biomass (Oliveira et al., 2021). Microalgae can also enhance plant growth by acting as a slow-release organic fertilizer to provide assimilated nutrients from wastewater and prevent contamination of soils and water bodies (Coppens et. al, 2016). The Figure 2 below is shown as *T. obliquus*.

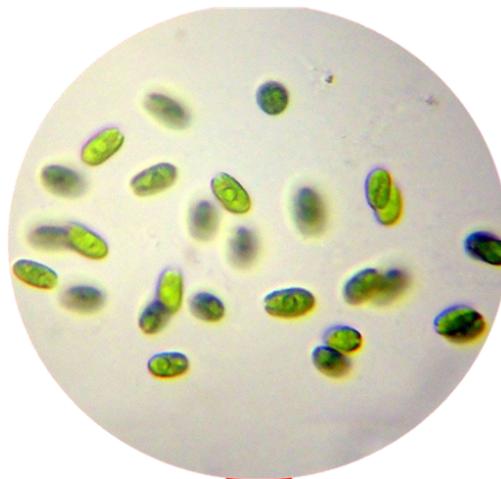


Figure 2. *Tetrademus obliquus* at optical microscopy.

The integration of microorganisms, particularly PGPR, and microalgae into agricultural and agroecological systems holds significant promise from an engineering perspective in advancing the development of renewable energy sources. Microbial inoculants, such as PGPR, offer a sustainable alternative to the extensive use of agrochemicals and fertilizers, potentially reducing the environmental impact associated with conventional farming practices.

Moreover, the symbiotic relationship established by PGPR with plants, leading to increased root growth and higher biomass yield, can contribute to the cultivation of energy crops like switchgrass and sugarcane, which serve as feedstocks for biofuel production. In parallel, the incorporation of microalgae with their capacity for efficient photosynthesis and lipid accumulation offers the potential for a dual benefit. These microorganisms can not only act as slow-release organic fertilizers, aiding in the sustainable growth of energy crops, but they can also serve as feedstock to produce biofuels themselves.

Furthermore, the bioactive properties of microalgae, including their antioxidant and antimicrobial capabilities, can support the development of bioenergy systems while mitigating environmental concerns. Consequently, the compatibility of bioinoculant bacteria and microalgae in enhancing root growth, as examined in this study, presents an intriguing avenue for engineering-driven innovations in the production of renewable energy and the sustainable management of agricultural ecosystems (Wang et al., 2022). With that in mind, this study is being carried out to

evaluate the compatibility of commercially available bioinoculant bacteria, from the bioinoculant Pastomax and the use of microalgae in the root growth of São Carlos grass.

## 2. THEORETICAL BACKGROUND

### 2.1 BIOFERTILIZERS

Biofertilizers are the final product resulting from the decomposition of organic compounds, which contain microorganism cells. These fertilizers are obtained through the decomposition of organic and mineral materials through anaerobic or aerobic digestion, with the aim of increasing the availability of nutrients and microorganisms (Marrocos et al., 2012). The chemical composition of biofertilizers varies according to the method of preparation, the time of decomposition, the microbiological population, the temperature and pH of the compound, in addition to the source material. One of the main characteristics of biofertilizers is the presence of microorganisms, which are responsible for the decomposition of organic matter and the release of metabolites, enzymes, vitamins, toxins, phenols, esters, acids and antibiotics (Medeiros & Lopes, 2006).

Biofertilizers contain essential nutrients for plant growth, and the concentrations of these nutrients vary according to the origin of the organic materials used and the time of decomposition. However, there is no established standard formula for the preparation of biofertilizers, which has led to a variety of recipes tested and used for different purposes (Morocos et al., 2012).

### 2.2 MICROALGAE

Single-celled microorganisms known for their rapid reproduction and can be categorized as autotrophic or heterotrophic based on their biological characteristics are microalgae (Chisti, 2007). They demonstrate the remarkable ability to thrive in challenging environments, including saline or brackish aquatic settings (Furlan et al., 2020). These microalgae can be cultivated through various methods (da Silva et al. 2022; Harun et al., 2010), such as open tanks found in natural lakes and ponds, as well as in an industrial setting using photobioreactors (PBRs), as shown Figure 3:

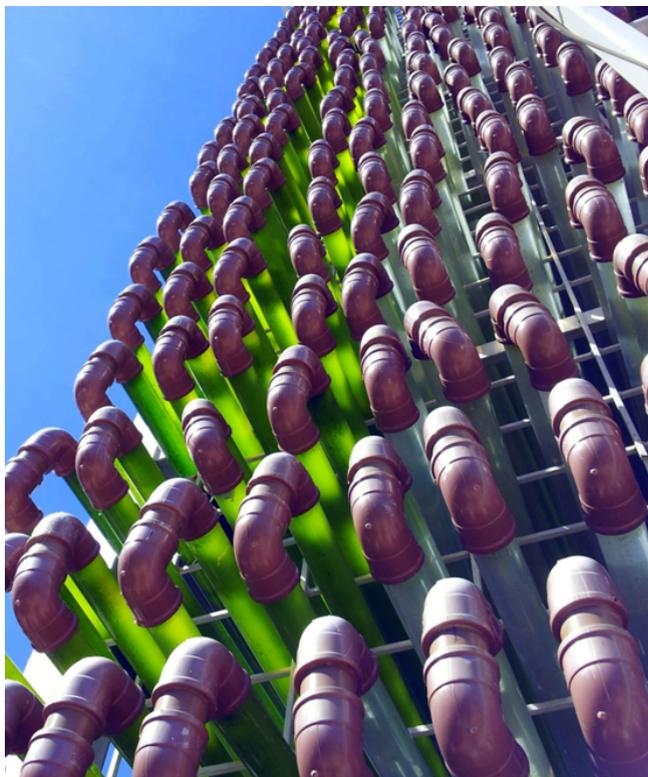


Figure 3. PBR with microalgae at NPDEAS, UFPR.

One of the crucial roles of microalgae is their significant contribution to photosynthesis on Earth, as they inhabit vast areas in the environment (Lehmuskero, 2018). Moreover, they play a vital role in environmental bioremediation, purifying the atmosphere through the photosynthesis process, which not only facilitates their growth but also enhances

the oxygen levels in the environment (Dermer et al., 2006). For the proper growth and sustenance, microalgae require specific nutrients, including organic carbon, solar energy, and inorganic sources like nitrates and phosphates, which are present in their surrounding media (Borowitzka, 2020).

There are three main types of microalgae cultivation: heterotrophic, autotrophic, and mixotrophic. Photoautotrophs depend on light as their primary energy source for nutrient production. In contrast, heterotrophic cultures need a supply of carbon within the culture medium to support their energetic development (Jacob-Furlan et al., 2021). Mixotrophic cultures, on the other hand, receive their food from inorganic, organic, and metabolic sources (e.g., sugars), and in combination with light, allow for photosynthesis and assimilation of organic sources (Furlan et al., 2020).

### 2.3 MICROALGAE AS RENEWABLE ENERGY

The use of microalgae as sustainable and renewable energy was initially proposed in 1960, but due to the oil crisis in 1970, research began to gain momentum and studies began on the use of microalgae as an energy source, enabling the identification of species with high potential for use (Gazzoni, 2016). Currently, there are more than 150 species of algae that are used commercially (Martins et al., 2012). However, little is known about the fact that algae and plankton can be used as biomass for the production of biofuels.

Microalgae, in particular, are photosynthetic organisms that can reach up to 2 mm in diameter and are considered more promising than macroalgae for oil production for renewable energy production. This is due to its less complex structure, faster growth rate and some species have a high oil content in their composition (Biodiesel, 2006), as Figure 4 demonstrates the fractions of biodiesel from microalgae.



Figure 4. Fractions of biodiesel from microalgae *T. obliquus* at NPDEAS, UFPR.

Regarding oil yield, that of microalgae is at least fifteen times greater than that of palm, which is the plant that provides the highest productivity by conventional means (Schenek, 2008). There are estimates of microalgae oil production between 5000 and 30000 L km<sup>-2</sup> (Benemann, 2008).

### 2.4 MICROALGAE AS BIOFERTILIZERS

Microalgae are unicellular organisms, which may or may not form colonies, photosynthesis that occur naturally in various aquatic environments. They can be used as raw material for the production of a wide range of bioproducts, such as biofertilizers, biofuels, chemicals, polymers, animal feed, food supplements, among others (Trichez et al, 2019). Among the extremely important areas in which microalgae can act, the use of microalgae as biofertilizers, in the treatment of effluents associated with agricultural waste and in the production of bioenergy stand out (Costa & Morais, 2011). With this, there is an opportunity to reduce the use of chemical products and the introduction of the use of microalgae as biofertilizers, in a total or partial exchange of conventional chemicals (Aghili et al., 2014).

Biofertilizers produced from microalgae help capture carbon dioxide from the atmosphere, fix nitrogen in the soil (Elbert et al., 2012), help improve soil porosity (Sahu et al., 2012), retain water in the soil, in addition to producing vitamins, amino acids and hormones beneficial to plants (Rodriguez et al., 2006). Using microalgae in the inoculation of cultures promotes the production of defense enzymes, transporters and chelating agents, among other beneficial substances. These compounds help plant growth, increase crop yields and strengthen plant immunity against diseases caused by pathogens (Gupta et al., 2013). In addition, the presence of microalgae improves fruit quality, nutritional characteristics and grain yield of crops (Coppens et al., 2016). It also promotes beneficial interactions between microbial organisms present in the soil, which contributes to the health and balance of the agricultural ecosystem as a whole (Karthikeyan et al., 2007).

## 2.5 GROWTH INDUCTORS

Growth regulators are natural or synthetic compounds that, in small concentrations, promote, inhibit or trigger a series of physiological processes in plant growth and development, with significant effects on the expression of productive potential (Hawerth et al., 2016). Growth inducers can promote plant growth through direct or indirect mechanisms (vejan et al., 2016). Directly, they improve the absorption and accumulation of essential nutrients by plants (Schlaeppli & Bulgarelli, 2015), perform biological nitrogen fixation, solubilize phosphates and secrete siderophores (Bashan et al., 2013), in addition to producing phytohormones (González et al., 2011). Indirectly, they play an important role in controlling pests and pathogens (Liotti et al., 2018) and induce plant resistance to biotic and abiotic stresses, such as heavy metals, water deficiency and salinity (Pietro Souza et al., 2020).

Inducers also promote root growth, aiding in the rapid establishment of lateral and adventitious roots. This characteristic is advantageous for plants, as it increases their ability to stick to the soil and obtain water and nutrients from the environment (Moreira & Araújo, 2013).

## 3. METHODOLOGY

The study was conducted with two PGPR: *Pseudomonas fluorescens* CNPSO 2719, *Azospirillum brasilense* CNPSO 2083 and 2084, inoculated individually or combined (bioinput Pastomax, Biotrop, Curitiba), and using the microalgae *Tetradismus obliquus* at 1.5%.

The inoculations were made with foliar application of solutions containing the microorganisms on an area of São Carlos grass of 0.5m<sup>2</sup> each. The treatments were:

- T1 - control;
- T2 - inoculated with Pastomax (commercial inoculant containing *A. brasilense* CNPSO 2083 and 2048 and *P. fluorescens* CNPSO 2719) in the soil (20 µL/m<sup>2</sup>), 150 mL per plot;
- T3 - inoculated with *P. fluorescens* CNPSO 2719 only;
- T4 - inoculated only with *A. brasilense* CNPSO 2083 and 2048;
- T5 - inoculated with 1.5% *T. obliquus* algae suspension. Each treatment was repeated twice.

### 3.1 ISOLATED INOCULANTS

The bioinput Pastomax brings the syrups of *A. brasilense* and *P. fluorescens* in separate bags. At the time of application, the user must mix the two mixtures.

Therefore, for the individual inoculation of bacteria, both *P. fluorescens* CNPSO 2719 and *A. brasilense* CNPSO 2083 and 2084, it was necessary to dilute 10mL of each syrup in 500mL of water and apply 150mL for each m<sup>2</sup> of grass, that is, 75mL for each repetition plot.

### 3.2 COMBINED INOCULANTS

The combined inoculation of bacteria was obtained after mixing 150mL of each inoculant and diluting 10mL of this mixture in 500mL of water, following the manufacturer's recommendation of 20 µL/m<sup>2</sup>.

Thus, 150mL were applied for each m<sup>2</sup> of grass, corresponding to 75mL for each repetition plot.

### 3.3 MICROALGAES

1.5g of microalgae macerated in 100mL of water was used and diluted in 500mL of water for application, resulting in an application of 150mL per square meter of grass, that is, 75mL per repetition plot.

## 4. RESULTS AND DISCUSSION

The study was conducted in a completely randomized experimental design, with two replications.

The repetitions followed, later, in analysis of chlorophyll content, leaf growth and root growth, aiming to understand the behavior of microalgae and bacteria when used as plant biostimulants.

The repetitions indicate in the chlorophyll content analysis, as shown in Table 1, that the use of microalgae *T. obliquus* showed a higher nitrogen content in the plants of 42.85 in the two replicates evaluated. The use of *A.*

*brasilense* resulted in a chlorophyll index of 41.34 (value given by the equipment, dimensionless) in the leaf analysis, also showing improvement in relation to the test treatment, without inoculants of 40.08 (idem). The use of *P. fluorescens* and Pastomax showed lower values than the control, 38.53 and 38.1 (idem), respectively.

The analysis of leaf growth and root growth in order to understand the behavior of microalgae and bacteria when used as plant biostimulants are still being observed.

Table 1: Analysis of chlorophyll content under different treatments

Average chlorophyll content	Treatment 1	Treatmente 2	Average
<i>Azospirillum brasilense</i>	39,14	43,54	41,34
<i>Tetrademus obliquus*</i>	43,08	42,62	42,85
<i>Pseudomonas fluorescens</i>	38,46	38,6	38,53
Pastomax	37,4	38,8	38,1
Negative Control	38,32	41,84	40,08

\*As microalgae

As noted, microalgae, due to their functional characteristics, fast growth and ease of production, offer a new perspective for biological industrialization through the development of biofertilizers. The large-scale production of biofertilizers using microalgae is a sustainable process that provides a product that stimulates plant growth without contaminating the environment.

This approach represents an organic alternative in the production of crops, ensuring the health of both the producer and the consumer, by developing products free of agrochemicals that are harmful to health. It is feasible to continue research in the field of microalgae to obtain more information and use these products not only in agriculture, but also in different areas, such as health, industry, cosmetics formulation and human and animal nutrition.

Therefore, microalgae and its various uses in various sectors, such as agriculture, livestock and biotechnology, can be a successful alternative and should be more widespread in the national territory, considering the positive effects they have (Brasil, 2016).

## 5. CONCLUSION

Based on the measured leaf chlorophyll levels using a portable meter, it is evident that the utilization of microalgae has demonstrated exceptional efficiency in sequestering atmospheric nitrogen within grasses, consistently yielding the highest recorded values when compared to alternative treatments. Conversely, the anticipated synergistic effects of combining the two inoculants, including the utilization of Pastomax, did not yield the significant results initially expected. These findings underscore the pivotal role of microalgae in enhancing nitrogen fixation, offering a promising avenue for engineering-driven approaches aimed at bolstering the sustainable production of renewable energy resources.

The nitrogen-fixing capacity exhibited by microalgae showed potential to improve the engineering of renewable energy systems, primarily through the optimization of energy crop growth and feedstock suitability for biofuel production. Simultaneously, the study's findings highlight the significance of comprehensive research in uncovering the synergistic dynamics between various microbial agents, further empowering engineering efforts to promote sustainable and environmentally responsible bioenergy solutions.

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## 7. REFERENCES

- AGHILI, F., Jansa, J., Khoshgofarmanesh, A. H., Afyuni, M., Schulin, R., Frossard, E., y Gamper, H. A. (2014). Wheat plants invest more in mycorrhizae and receive more benefits from them under adverse than favorable soil conditions. *Applied Soil Ecology*, 84, 93–111.
- ATKINSON, D.; WATSON, C. A. The beneficial rhizosphere: a dynamic entity. *Applied Soil Ecology*, v. 15, n. 2, p. 99-104, 2000.
- BASHAN, Y., Kamnev, A. A. & Bashan, L. E. (2013). Tricalcium phosphate is inappropriate as a universal selection factor for isolating and testing phosphatesolubilizing bacteria that enhance plant growth: A proposal for an alternative procedure. *Biology and Fertility of Soils*, 49 (1), 465-479.
- BENEMANN, J.R., overview: Algae oil to Biofuels, National Renewable Energy Laboratory - Air Force Office of Scientific Research Workshop on Algal Oil for Jet Fuel Production - February, 2008
- BERTOLDI, Fabiano Cleber; SANT’ANNA, ERNANI; OLIVEIRA, Jorge Luiz Barcelos. Revisão: Biotecnologia de microalgas. *Boletim do Centro de Pesquisa de Processamento de Alimentos*, v. 26, n. 1, p. 9-20, 2008.
- BIODIESEL DE ALGAS. 2006. Disponível em: . Acesso em: 10 de julho de 2023.
- BOROWITZKA, M. A., 2020. “Handbook of Microalgae-Based Processes and Products”. Academic Press, 27-30
- BRASIL, B.S.A.F.; GARCIA, L.C. Microalgas: alternativas promissoras para a Indústria. *Agroenergia em Revista*, v.10, n. 10, p. 9, 2016.
- BUMANDALAI, O., TSERENNADMID, R., 2019. Effect of *Chlorella vulgaris* as a biofertilizer on germination of tomato and cucumber seeds. *Int. J. Aquat. Biol.* 7, 95–99.
- CHENK P., Second generation biofuels: high-efficiency microalgae for biodiesel production. *Bio energy research*, n.1, v.1, p.20–43, 2008.
- CHISTI, Y., 2007. “Biodiesel from Microalgae”. *Biotechnology Advances*, vol. 25, p. 294-306
- CONTI, Raphael; GUIMARÃES, Denise O.; PUPO, Mônica T. Aprendendo com as interações da natureza: microrganismos simbioses como fontes de produtos naturais bioativos. *Ciência e Cultura*, v. 64, n. 3, p. 43-47, 2012
- COPPENS, J., Grunert, O., Van Den Hende, S., Vanhoutte, I., Boon, N., Haesaert, G., De Gelder, L., 2016. The use of microalgae as a high-value organic slow-release fertilizer results in tomatoes with increased carotenoid and sugar levels. *J. Appl. Phycol.* 28, 2367–2377.
- COSTA, J.A.V.; MORAIS, M.G. The role of biochemical engineering in the production of biofuels from microalgae. *Bioresource Technol.*, v.102, p.2-9, 2011.
- COSTA, Pedro Beschoren da. Isolamento e caracterização de bactérias promotoras de crescimento vegetal de lavouras experimentais de arroz sob diferentes níveis de fertilização. 2012.
- DA SILVA, Paulo Alexandre S. et al. Phycoremediation: Role of Microalgae in Waste Management and Energy Production. In: *Waste-to-Energy: Recent Developments and Future Perspectives towards Circular Economy*. Cham: Springer International Publishing, 2022. p. 511-537.
- DERNER, R. B.; OHSE, S.; VILLELA, M.; CARVALHO, S.M.; FETT, R., 2006. “Microalgas, produtos e aplicações.” *Ciência Rural*, v. 6, p. 1959 -1967, 2006
- FURLAN, B.J., Zatta, PHS; Antezana, VCP; Martins, LS, Mariano, AB., 2021. “Estudo do crescimento de microalgas em meio de cultivo CHU e dejetos suínos.” *Meio Ambiente, Sustentabilidade e Tecnologia*, Volume 6. 1ed. Belo Horizonte, Minas Gerais.: Editora Poisson, v.6, p. 204-211
- GARCÍA-ORELLANA, Y., Soto, G., Tafur, V., Simbaña, A., Tello, E., y Brito, J. (2016). Efecto de un Fertilizante Or-gánico Microalgal en la Germinación y Crecimiento de Plántulas de Albahaca (*Ocimum basilicum* L.). *Revis-ta Unellez de Ciencia y Tecnología*, 34, 33–39.
- GAZZONI, Décio Luiz. Os desafios do biodiesel de algas. 2016c. Disponível em: . Acesso em: 14 maio 2016.
- GONZÁLEZ, C. R., Aguilar, L. M., Trujillo, A. R., Santos, P. E., Mellado, C. J., Santos, P. & Mellado, J. C. (2011). High diversity of culturable *Burkholderia* species associated with sugarcane. *Plant and Soil*, 345 (1), 155-169
- HARUN, R., Singh, M., Forde, G.M., Danquah, M.K., 2010. “Bioprocess engineering of microalgae to produce a variety of consumer products.” *Renew. Sustain. Energy. Rev.* 14 (3), 1037e1047. <https://doi.org/10.1016/j.rser.2009.11.004>.
- HAWERROTH, Fernando José et al. Reguladores de crescimento, importância, perspectivas e utilização. *Seminário Nacional sobre Fruticultura de Clima Temperado*, v. 12, 2016.
- JACOB-FURLAN, B., Zatta, PHS., Gonçalves, RSR., Silva, PAS., Martins, LS., Ordonez, JC., Vargas, JVC., Mariano, AB., 2021. “MICROALGAE AS SOURCE OF RENEWABLE ENERGY: A REVIEW”. In: 26

- th ABCM International Congress of Mechanical Engineering. November 22-26, 2021. Florianópolis, SC, Brazil. doi: <http://dx.doi.org/10.26678/abcm.cobem2021.cob2021-0548>
- KAWALEKAR J. S. (2013): Role of biofertilisers and biopesticides for sustainable agriculture. *Journal of Bio Innovation*, 2
- LEHMUSKERO, A., Chauton, M. S., and Bostrom, T. (2018). "Light and photosynthetic microalgae: A review of cellular- and molecular-scale optical processes." *Progress in Oceanography*, 168, 43–56. Elsevier. doi:10.1016/j.pcean.2018.09.002.
- LIOTTI, R. G., Figueiredo, M. I. S., Silva, G. F., Mendonça, E. A. F. & Soares, M. A. (2018). Diversity of cultivable bacterial endophytes in *Paullinia cupana* and their potential for plant growth promotion and phytopathogen control. *Microbiological Research*, 207 (1), 8-18
- MARROCOS, SAULO DE TARCIO PEREIRA et al. Composição química e microbiológica de biofertilizantes em diferentes tempos de decomposição. *Revista Caatinga*, v. 25, n. 4, p. 34-43, 2012.
- MARTINS, Marcio Arêdes et al. Nota técnica: as microalgas como alternativa à produção de biocombustíveis. *Revista Engenharia na Agricultura-REVENG*, v. 20, n. 5, p. 389-403, 2012.
- MEDEIROS, M. B.; LOPES, J. S. Biofertilizantes líquidos e sustentabilidade agrícola. *Bahia Agrícola*, Salvador, v. 7, n. 3, p. 24-26, 2006.
- MOREIRA, A. L. L. & Araújo, F. F. (2013). Bioprospecção de isolados de *Bacillus* spp. como potenciais promotores de crescimento de *Eucalyptus urograndis*. *Revista Árvore*, 37 (5), 933-943
- OLIVEIRA, Carlos Yure B. et al. A multidisciplinary review of *Tetrademus obliquus*: a microalga suitable for large-scale biomass production and emerging environmental applications. *Reviews in Aquaculture*, v. 13, n. 3, p. 1594-1618, 2021.
- PEREIRA, Claudio MP et al. Biodiesel renovável derivado de microalgas: avanços e perspectivas tecnológicas. *Química Nova*, v. 35, p. 2013-2018, 2012.
- PIETRO SOUZA, W., Campos Pereira, F., Mello, I. S., Stachack, F. F. F., Terezo, A. J., Cunha, C. N., White, J. F., Li, H. & Soares, M. A. (2020). Mercury resistance and bioremediation mediated by endophytic fungi. *Chemosphere*, 240, 1-42
- SCHLAEPPPI, K. & Bulgarelli, D. (2015). The Plant Microbiome at Work. *Molecular Plant Microbe Interactions*, 28 (3), 212-217
- SINGH, S., Singh, V. & Pal, K. (2017). Importance of microorganisms in agriculture. *Climate and Environmental changes: Impact, Challenges and Solutions*, 1, 93-117.
- TRICHEZ, D.; BERGMANN, J. C.; GARCIA, L. C. and JUNGMANN, L. How many bioethanol generations can we have? In: TREICHEL, H.; ALVES JÚNIOR, S. L.; FONGARO, G.; MÜLLER, C. Ethanol as a green alternative fuel: insight and perspectives. Hauppauge, NY: Nova Science Publishers, cap. 2. p. 21-25, 2019.
- VEJAN, P., Abdullah, R., Khadiran, T., Ismail, S. & Boyce, A. N. (2016). Role of Plant Growth Promoting Rhizobacteria in Agricultural Sustainability — A Review. *Molecules*, 21 (5), 673-693.
- Wang, S., Mukhambet, Y., Esakkimuthu, S., & Abomohra, A. E. F. (2022). Integrated microalgal biorefinery – Routes, energy, economic and environmental perspectives. In *Journal of Cleaner Production* (Vol. 348). Elsevier Ltd. <https://doi.org/10.1016/j.jclepro.2022.131245>

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