DOI: https://doi.org/10.17921/1415-6938.2024v28n3p298-303

Commercial Bioinput in Sugarcane Culture

Bioinsumo Comercial na Cultura de Cana de Açúcar

Bruna Fernanda Albertti*[a]; Josemeyre Bonifácio da Silva Marques[b]; Hélio Hiroshi Suguimoto[c]; Flavio Faedo Aguena[c]; Denise Renata Pedrinho[c]; Bianca Obes Correa[c]; José Antônio Maior Bono[c]

[a]Centro Universitário Anhanguera de São Paulo, Programa de Pós-Graduação em Biotecnologia e Inovação em Saúde. SP, Brasil.
[b]Universidade Anhanguera Unopar. PR, Brasil.
[c]Universidade Anhanguera Uniderp, Programa de Pós-graduação em Agronegócio Sustentável. MS, Brasil.
*E-mail: bruna.albertti@zbiotec.com.br

Abstract

The objective of this work was to verify the effect of different doses of commercial bioinputs on the physical-chemical characteristics and productivity of the sugarcane crop. The doses used were 0.5; 1.0 and 2.0 L ha^{-1} of commercial bioinputs, in the planting furrow and cover, 30 days after transplanting the seedlings. The nutrients in the leaf blade that had a positive response to the doses of bioinputs were phosphorus, potassium, sulfur and manganese. For the length of the stems, the dose of 2.0 L ha^{-1} was the one that presented the most expressive results, with the application in coverage provided a greater length of stem with 2.08 m, and the application in the furrow, 1.99 m. The commercial bioinput, in coverage, provided an increase in plant height, suggesting a possible hormonal change in the plants. The use commercial bioinput in the sugarcane culture had a benefit of around 20 t ha^{-1} regarding the productivity of the stalks. The commercial bioinput is efficient in providing P, K and S when applied in the furrow of the sugarcane culture and in the absorption of Mn, when applied in coverage, and increases the productivity of stalks in the sugarcane culture.
Keywords: Biological Product. Microorganisms. Sustainability. Nutrients.

Resumo

O objetivo deste trabalho foi verificar o efeito de diferentes doses de bioinsumo comercial nas características físico-químicas e na produtividade da cultura da cana-de-açúcar. As doses do bioinsumo utilizadas foram 0,5; 1,0 e 2,0 L ha^{-1}, no sulco e cobertura de plantio, 30 dias após o transplante das mudas. Os nutrientes da lâmina foliar que responderam positivamente às doses do bioinsumo foram fósforo, potássio, enxofre e manganês. Para o comprimento das hastes, a dose de 2,0 L ha^{-1} foi a que apresentou resultados mais expressivos, sendo que a aplicação em cobertura proporcionou maior comprimento de haste com 2,08 m, e a aplicação no sulco, 1,99 m. O bioinsumo comercial, em cobertura, proporcionou aumento na altura das plantas, sugerindo uma possível alteração hormonal nas plantas. A utilização de bioinsumo comercial na cultura da cana-de-açúcar proporcionou um benefício em torno de 20 t ha^{-1} em relação à produtividade dos colmos. O bioinsumo é eficiente no fornecimento de P, K e S quando aplicado no sulco da cultura da cana-de-açúcar e na absorção de Mn, quando aplicado em cobertura, e aumenta a produtividade de colmos na cultura da cana-de-açúcar.
Palavras-chave: *Produto Biológico. Microrganismos. Sustentabilidade. Nutrientes.*

1 Introduction

The search for alternatives that are friendly to the environment and animal and human health, ensuring competitive productivity yields and meeting the growing demand for food, are among the main challenges of sustainable development established by the United Nations (UN) and whose goals must be achieved by the year 2030 (De Abreu; Lima; Lemos, 2023). Bioinputs today constitute a new technological promise that opens up the possibility of reconciling interests within the agricultural field, offering innovative solutions to respond to an increasing growth on the part of consumers and the productive sector that demand alternatives to the expressive use of costly agrochemicals and pesticides from an economic, environmental and health point of view (Goulet, 2021; Srivastava *et al*., 2019). These bioproducts are natural preparations, such as seaweed extracts, humic substances, amino acids, and beneficial microorganisms, which have gained importance as biostimulants and bioprotectors and which have aroused great interest due to their role in improving productivity and reducing the impact of biotic and abiotic stresses (Marques *et al*., 2022). The market for biological inputs is growing worldwide, in the case of biofertilizers, the estimate made for 2022 was US$ 2.02 billion, reaching US$ 4.47 billion in 2029, a growth of 12.04 %. To biostimulants (microorganisms, extracts, enzymes, etc.) the estimate was US$ 3.14 billion in 2022, going to US$ 6.69 billion in 2029, an increase of 11.43 % (Joshi; Gauraha, 2022; Saritha; Tollamadugu, 2019). The beneficial effects of bioproducts can be seen in various agricultural crops such as wheat (Kumar; Brar, 2021; Trivedi *et al*., 2020), sorghum (Jakhad; Debbarma, 2023), spinach (Singh *et al*., 2021), bean (Marques *et al*., 2022). The concern with high quality and sufficient food to feed the world's population, in addition to the use of more sustainable products for production systems, are themes that are widely discussed by Boaretto *et al*. (2014). Sugarcane (*Saccharum* spp.) is a crop of great economic importance in the Brazilian agroindustrial sector, with Brazil being the largest producer and exporter of sugar (Marin *et al*., 2019). The advance of sugarcane planting leads to numerous gains, such as the mitigation of degraded areas, nutrient cycling, maintenance of carbon in the soil, production of bioenergy sources and influence in the economic and social scope of expanding regions (Cherubin *et al*., 2021). The production systems for the sugarcane culture in Brazil also have to enter into this theme of the use of biological products that can significantly contribute to the nutritional part of this culture. Civieiro *et al*. (2014) verified that the humic substances, applied to the mini stalk at planting, influenced the root length, root surface area, dry mass of the root system and dry mass of the aerial part of sugarcane. However, there are contradictory results regarding the use of biological products. Pereira and Rosa-Magri (2021) did not observe beneficial effects of replacing conventional chemical fertilization with the use of vinasse, with inoculation of *Nitrispirillum* amazonense (diazotrophic bacteria). The supply of nutrients via fertilization is a crucial step to maintain high levels of productivity in a sugarcane field (Oliveira *et al*., 2020). Therefore, it is fundamental to search for more efficient sources for soil fertilization, guaranteeing cost reduction and, at the same time, safety in the sugarcane production chain. The commercial bioinput is a bioactive compound, obtained through the fermentation of organic compounds, which contains living or latent cells of microorganisms and their metabolites such as enzymes, antibiotics, amino acids, organic acids and phytohormones. The different microbial groups that make up the commercial bioinput, such as lactic acid bacteria, yeasts, actinobacteria and *Bacillus* sp. produce the metabolites mentioned above, which will be fundamental for the development of plants. These microorganisms are beneficial agents, both for plants and for the soil, as they promote the improvement of their structural quality and plant health, in order to become an indispensable tool in enhancing the cycling of nutrients and favoring the natural processes of ecosystems. (Cargnelutti *et al*., 2021). Current challenges, the objective of this study was to evaluate the effects of different doses of the commercial bioinput, developed by the brazilian company ZBiotec, on the physical-chemical characteristics and productivity of the sugarcane crop.

2 Material and Methods

The experiment was conducted from September 2021 to October 2022, at School Farm Três Barras at Anhanguera Uniderp University (Campo Grande, MS), located at geographic coordinates 20°34’8.60”S and 54°32’28.65”, with an elevation of 560 m above sea level and a rainfall regime of 1530 mm per year. The soil in the region is classified as dystrophic red Latosol and the climate according to the Köppen-Geiger classification is tropical with a dry season (Aw).

The commercial bioinput, developed and supplied by the brazilian company ZBiotec (Limeira, São Paulo, Brazil), is a bioactive liquid, obtained through the fermentation of organic compounds, (extracts of vegetable origin and sugarcane molasses) and viable microorganisms (lactic bacteria, yeasts, actinobacteria, photosynthetic bacteria and *Bacillus sp*.). To activate the bioinput, the manufacturer’s recommendation is to use sugar or cane molasses and wait 48 h for its application.

The tested treatments were: the control with 0 L ha^{-1} of the product; treatment with 0.5 L ha^{-1} of the product Commercial bioinput, treatment with 1.0 L ha^{-1} of Commercial bioinput and 2.0 L ha^{-1} of Commercial bioinput in two application forms, in the planting furrow and in coverage, 30 days after transplanting the seedlings, thus totaling 8 treatments.

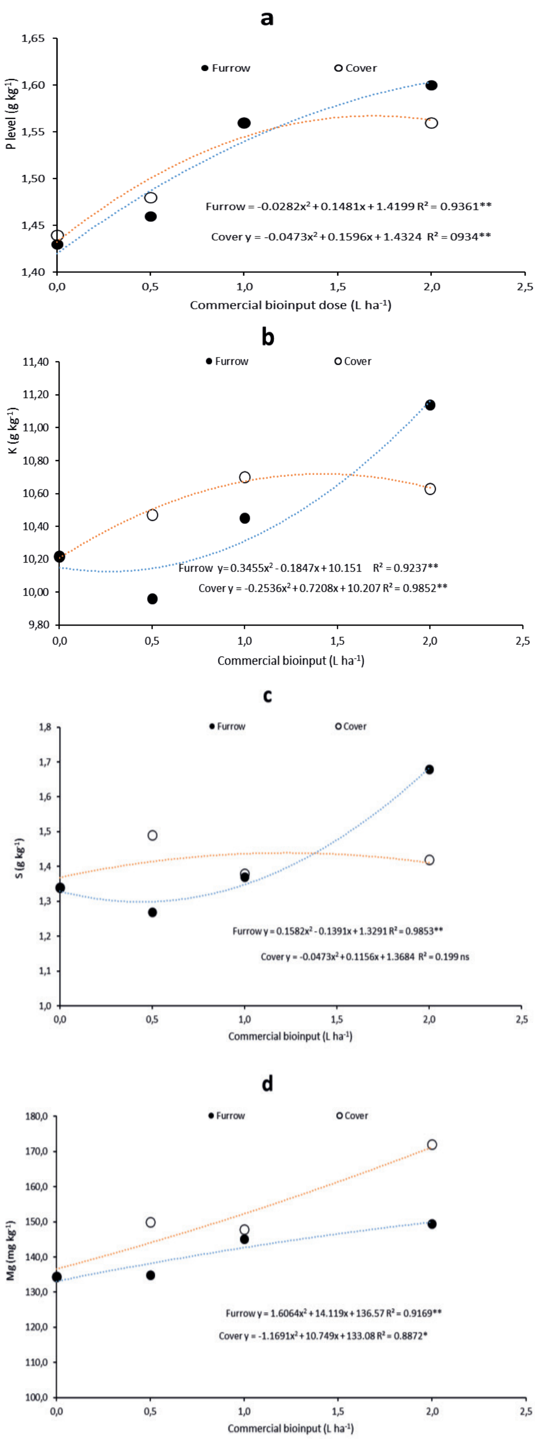
Sugarcane, variety IACSP-96-7569, was planted using the pre-sprouted seedlings (PSS) method. The seedlings were produced in the university greenhouse and conducted in a greenhouse for 2 months until planting in the experimental area. Planting took place in November 2021 using spacing of 1.40 m between rows and 0.50 m between seedlings. Before setting up the experiment in the field, soil preparation operations were carried out with the passage of a heavy harrow with a 32” disc, moldboard-type plow to uncompact the layers below 25 cm and then the application of 2000 kg ha^{-1} of 85 % PRNT dolomitic limestone, incorporated with the leveling grid. Soon after, 400 kg ha^{-1} of NPK fertilizer (04-30-10) was applied in the total area and incorporated with a leveling grid. The experimental plots had the dimensions of 5 m long by 5.6 m wide. For analysis of foliar macro and micronutrient contents (Embrapa, 2011), 4 months after transplanting the seedlings, the leaf blade (leaf +3) was collected, totaling 30 leaves per experimental plot. The leaves were dried in an oven at 65 °C with forced air circulation and ground in a Wille-type mill. Seven months after transplanting, sugarcane tillers and plant height (cm) were counted, using the soil surface up to leaf +1 as a reference. The cutting of the stems took place in October 2022, carried out close to the ground and in the useful plot, removing the part of the heart of palm and measuring their mass (g) and extrapolating to t ha^{-1}.

The experimental design was randomized blocks with 4 replications per treatment consisting of a 4 x 2 factorial. The results were submitted to regression analysis, adjusting the models of significant equations by the F test, and using the program Sigma Plot® statistical.

3 Results and Discussion

The nutrients in the leaf blade that had a positive response to the doses of bioinputs were phosphorus, potassium, sulfur and manganese. For phosphorus (Figure 1a), both furrow and cover application, the data fit the quadratic crescent model, indicating an increase in the foliar nutrient content as the bioinput doses increased. The forms of application, furrow and covering, responded positively up to the amount of 2 L ha^{-1} reaching 1.55 g kg^{-1} of P in coverage, and 1.60 g kg^{-1} of P applied in the furrow. Application in the furrow provided a greater increase in the content of this nutrient.

Figure 1 - Phosphorus (a), potassium (b), sulfur (c) and manganese (d) levels in the sugarcane leaf blade, as a function of different doses of commercial bioinput, in two application times.

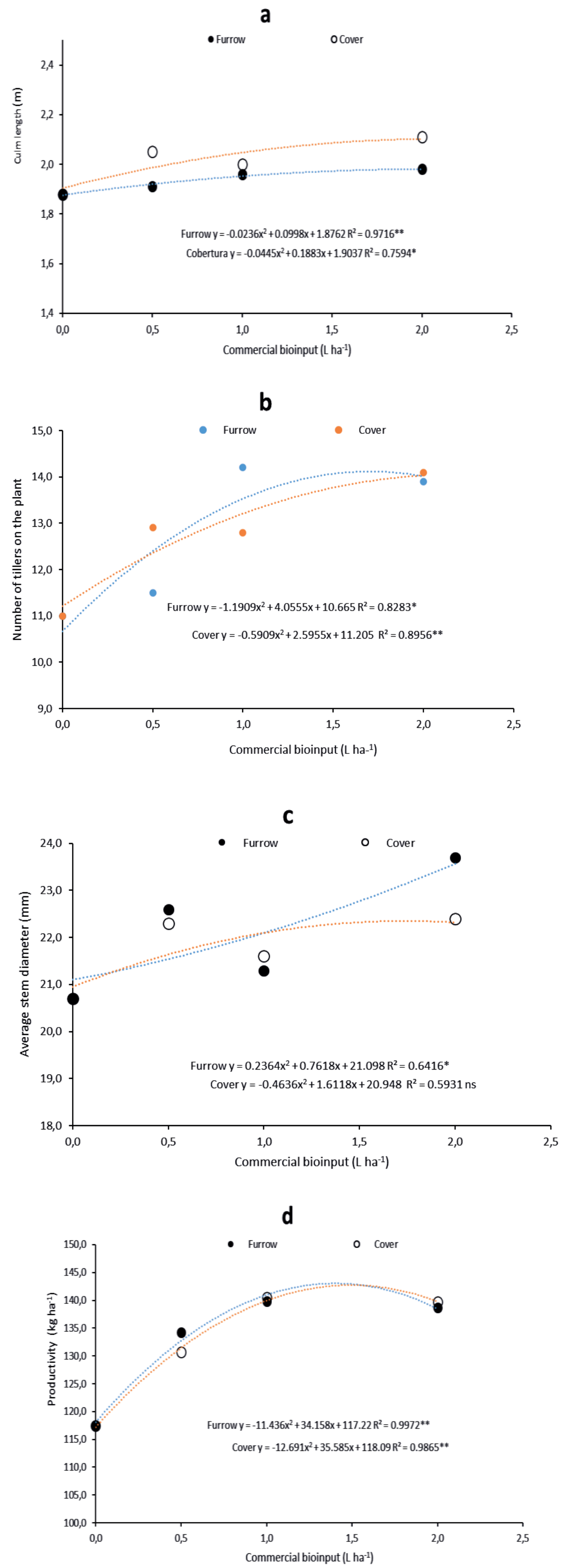


**significant at 1%.
Source: research data.

Phosphorus is one of the most important nutrients for the development and growth of plants, however, its application to the soil in large amounts and through phosphate fertilizers does not guarantee its use by plants (Reetz, 2017). An effective and sustainable alternative to make the nutrient available to plants would be the use of microorganisms, such as bacteria of the genera *Bradyrhizobium*, *Azopirillum*, *Bacillus*, *Gluconacetobacter*, *Pseudomonas* that contribute to plant growth through different processes that include phosphate solubilization (Vio *et al*., 2023). Thus, microorganisms solubilize inorganic phosphate into soluble phosphate mainly through the mechanism of producing mineral dissolution compounds, such as organic acids, siderophores, protons, hydroxyl ions and CO_2 (Alori *et al*., 2017). Therefore, the presence of microorganisms in the commercial product Commercial bioinput contributed to the promotion of root growth and, consequently, better absorption of phosphorus, since this mineral is an immobile element in the soil and its absorption by plants occurs mainly through the diffusion process (Abawari *et al*., 2020).

As with P, the results of foliar potassium content (Figure 1b), both in the furrow and in the cover, fit the quadratic increasing regression model, indicating an increase in the nutrient content as the bioinput doses increased. As the solid fraction of the soil corresponds to a reservoir of nutrients for the plants, the displacement of acids from the exchange sites by the activity of soil microorganisms allows the K+ to be better utilized by the plant. Like P, potassium is also mainly absorbed by the diffusion process (Reichardt; Timm, 2014). Thus, the application of Commercial bioinput again favored better root development due to the greater ability to neutralize soil acidity. The sulfur content (Figure 1c) in the leaf responded only to treatments with Commercial bioinput in the furrow, with the maximum content observed at the dose of 2.0 L ha^{-1}. About 85 to 90% of soil S is found in organic matter, most of which form bonds with amino acids or ester compounds (Cardoso; Andreote, 2016). When in mineral form, sulfur has different forms, from a highly reduced state (S_2-Sulphide) to a completely oxidized state (SO_4^{2}-Sulphate). However, sulfur is only absorbed by the plant when present in the soil solution as sulfate (SO^4_{2-}). In this sense, the action of the soil microbiota is fundamental for the mineralization of sulfur in organic matter and for its solubilization in sulfate ion, so that plants can absorb it (Ceretta; Aita, 2008). The bioproducts, therefore, can contribute to the development of the microbiota, and the application in the furrow would be more efficient in activating the soil microbiota. The sulfates present in the soil solution are also subject to the phenomenon of adsorption with the solid phase, similarly to what happens with phosphorus, but with a lower degree of intensity. Thus, sulfate can present poorly soluble forms when they are adsorbed by iron and aluminum oxides. The application of commercial bioinput in the furrow could be reducing the adsorption of sulfates. This adsorption mainly depends on the pH of the soil, the type and content of minerals, and the competition for exchange points with other anions such as hydroxyls (OH-) and soluble phosphorus ($H_2PO_4^-$ and HPO_4^{2-}), which would be positively influencing the soil fertility (Fernandes *et al.*, 2018). The manganese content (Figure 1d) increased as commercial bioinput doses increased. However, treatments with commercial bioinput in top dressing provided greater accumulation of Mn in the leaf compared to that applied in the furrow. Soil pH is the main factor that influences Mn availability (Malavolta, 2006), since the higher concentration of hydroxyls in the soil solution favors Mn precipitation through the formation of hydroxides, which cannot be absorbed by plants. Mn is absorbed by plants as the bivalent ion Mn^{2+}, when unavailable it is found as oxides (MnO_2) and hydroxides (MnOH) or in an oxidized state (Mn^{4+}, Mn^{3+}) and, like the other cationic micronutrients, are of little mobility in the plant (Silva; Berti, 2022). Cover application could be favoring the absorption and translocation of these micronutrients. For the length of the stems (Figure 2a), the doses of 2.0 L ha^{-1} were the ones that had the most expressive results, with the application in coverage provided a greater length of stem with 2.08 m, and the application in the furrow, 1.99 m. The commercial bioinput product, in coverage, provided an increase in plant height, suggesting a possible hormonal change in the plants, when applied in coverage. Microorganisms have the ability to improve plant growth through different processes such as nitrogen fixation, phytohormone production and phosphate solubilization, and can induce plant immune system components that help plants deal with abiotic and biotic stresses, among others. factors (Compant *et al.*, 2019). The number of tillers per plant (Figure 2b) responded positively to the increase in commercial bioinput doses. The two forms of application were very similar, with no significant differences between them. The average number of tillers was 13.2 in the furrow and 13.3 in coverage, values much higher than the 11 tillers verified in the control treatment. Bono *et al.* (2021) working with the same sugarcane cultivar in the same location and in the first cut also recorded mean values of 13.8 tillers per plant. The use of commercial bioinput positively influenced the mean diameter of the culms (Figure 2c), with emphasis on the dose of 2.0 L ha^{-1}, with the application in the furrow being superior to the application in the cover. Rocha *et al.* (2022), with potassium fertilization, observed a positive effect for the variables height and number of plants for sugarcane varieties. However, there was no significant effect for the stem diameter variable, however, the use of bioinput in the present study may have also contributed to the greater development of the stems. The reflexes of the positive effect of the plant's biometry, was manifested in the productivity, productivity of stems, responding positively with the doses of commercial bioinput (Figure 2d).

Figure 2 - Stem diameter (a), number of tillers on the plant, average values of stem length (c) and (d) sugarcane productivity, as a function of different doses of commercial bioinput, and in two seasons



*= significant at 5% **= significant at 1%.

Source: research data.

The average productivity of stalks applied in the furrow was 137.6 kg ha^{-1}, an increase of 20.kg t ha^{-1} in relation to the control treatment and the average coverage was 136.9 kg ha^{-1}, an increase of 19.4 kg ha^{-1} when compared to the control treatment. Productivity of p23.78 t ha^{-1} was observed bell pepper plants grown in soil with biofertilizer (Lima Neto *et al*., 2021).

Regardless of the form of application, the use of commercial bioinput in the sugarcane culture had a benefit of around 20 t ha^{-1} regarding the productivity of the stalks. *Bacillus megaterium* and *Bacillus subtilis* isolated from sugarcane plants exhibited healthy colonization within the root, indicating better plant growth performance and survival potential under adverse environmental conditions (Chandra *et al.,* 2021). Commercial bioinput contains viable microorganisms such as lactic acid bacteria, yeasts, actinobacteria, photosynthetic bacteria and *Bacillus* sp. and in this way, provided the sugarcane culture with favorable conditions for full growth and development, and this evidence can be confirmed through the results referring to the availability of nutrients for the plant, in the size and diameter of the stems and, consequently, in the productivity. The increase in the number of fruits and plant production provided by the use of the side coating of the ridges was reflected in the increase in productivity.

4 Conclusion

Commercial bioinput is efficient in providing the nutrients P, K and S when applied in the furrow of the sugarcane crop and in the absorption of Mn, when applied in coverage. The commercial biological product developed by the brazilian company ZBiotec, or bioinput, increases the productivity of stalks in the sugarcane culture.

References

ABAWARI, R.A.; TUJI, F.A.; YADETE, D.M. Phosphate solubilizing bio-fertilizers and their role in bio-available P nutrient: an overview. International J. Appl. Agricul. Sci., v.6, n.6, p.162, 2020. doi: https://doi.org/10.11648/j.ijaas.20200606.11

ALORI, E.T.; GLICK, B.R.; BABLOLA, O.O. Microbial phosphorus solubilization and its potential for use in sustainable agriculture. Front. Microbiol., v.8, 2017. doi: https://doi.org/10.3389/fmicb.2017.00971

BONO, J.A.M. et al. Evaluation of the agronomic efficacy of phosphatic limestone in phenological and productive development of sugarcane. Res., Soc. Develop., v.10, n.7, 2021. doi: https://doi.org/ 10.33448/rsd-v10i7.16762.

BOARETTO, A.E.; ABREU, J.R.C.A.; LAVRES, J.R. Os desafios da nutrição mineral de plantas. In: PRADO, R.M.; WADT, P.G.S. Nutrição e adubação de espécies florestais e palmeiras. Jaboticabal: FCAV/CAPES, 2014. p.27-53.

CARDOSO, E.J.B.N.; ANDREOTE, F.D. Microbiologia do solo. Piracicaba: ESALQ, 2016.

CARGNELUTTI, D. et al. Soluções tecnológicas emergentes para uma agricultura sustentável: microrganismos eficientes. In: GARCÍA, L.M.H. (Ed.), Agroecologia: princípios e fundamentos ecológicos aplicados na busca de uma produção sustentável. Canoas: Mérida, 2021. p.31-62. doi: https://doi.org/ 10.4322/mp.978-65-991393-9-0.c2

CERETTA, C.A.; AITA, C. Biologia do Solo. Santa Maria: Universidade Federal de Santa Maria, 2008.

CHANDRA, A.; CHANDRA, P.; TRIPATHI, P. Whole genome sequence insight of two plant growth-promoting bacteria (B. subtilis BS87 and B. megaterium BM89) isolated and characterized from sugarcane rhizosphere depicting better crop yield potentiality. Microbiol. Res., v.247, p.126-733, 2021. doi: https://doi.org/10.1016/j.micres.2020.126733

CHERUBIN, M.R. et al. Land use and management effects on sustainable sugarcane-derived bioenergy. Land, v.10, n.1, 2021. doi: https://doi.org/10.3390/land10010072

CIVIEIRO, J.C. et al. Aplicação de substância húmica e do aminoácido L-glutâmico em diferentes comprimentos da reserva nutricional de tolete de uma gema de cana-de-açúcar. Rev Ciênc. Agr., v.37, n.3, p.340-347, 2014. doi: https://doi.org/10.19084/rca.16833

COMPANT, S. et al. A review on the plant microbiome: Ecology, functions, and emerging trends in microbial application. J. Adv. Res., v.19, p.29-37, 2019. doi: https://doi.org/10.1016/j.jare.2019.03.004

De ABREU LIMA, R.; LEMOS, F. K.; LIMA, R.C.A.L. Brazilian Agriculture and the Global Environmental Agenda. In: SUSTAINABILITY CHALLENGES OF BRAZILIAN AGRICULTURE: GOVERNANCE, INCLUSION, AND INNOVATION. Cham: Springer International Publishing, 2023. p.85-105.

EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária. Manual de métodos de análise de solos. Rio de Janeiro: Embrapa Solos, 2011.

FERNANDES, M.S.; SOUZA, S.R.; SANTOS, L.A. Nutrição mineral de plantas. Viçosa: Sociedade Brasileira de Ciência do Solo, 2018.

GOULET, F. Biological inputs and agricultural policies in South America: between disruptive innovation and continuity. Perspective, v.55, 2021. doi: https://doi.org/10.1016/j.jare.2019.03.004

JOSHI, S.K.; GAURAHA, A.K. Global biofertilizer market: Emerging trends and opportunities. In: SONI, R. et al. Developments in applied microbiology and biotechnology: trends of applied microbiology for sustainable economy. Academic Press, 2022. doi: https://doi.org/10.1016/B978-0-323-91595-3.00024-0

JAKHAD, A.; DEBBARMA, V. Influence of biofertilizer and zinc on growth, yield and economics of sorghum (Sorghum bicolor L.). Int. J. Plant & Soil Sci., v.35, n.8, p.90-97, 2023. doi: https://doi.org/10.9734/ijpss/2023/v35i830947

KUMAR, P.; BRAR, S.K. Conjugation of biofertilizers with different sources of chemical fertilizers in wheat: a review. Agricul. Rev., v.42, n.1, p.22-31, 2021. doi: https://doi.org/10.18805/ag.R-1956

LIMA NETO, A.J.D. et al. Productivity and photosynthetic pigments in bell pepper plants grown in soil with biofertilizer and protected against water loss. Rev. Ceres, v.68, p.39-46, 2021. doi: https://doi.org/10.1590/0034-737X202168010006

MARQUES, B. et al. The Influence of Applications of Bio-Inputs Derived from Macroalgae and Bacteria on a Phaseolus vulgaris L. Crop. Front. Biosci., v.15, n.3, 2022. doi: https://doi.org/10.2741/SB1019

MALAVOLTA, E. Manual de nutrição mineral de plantas. São

Paulo: Agronômica Ceres, 2006.

MARIN, F.R. et al. On-farm sugarcane yield and yield components as influenced by number of harvests. Field Crops Res., v.240, p.134-142, 2019. doi: https://doi.org/10.1016/j.fcr.2019.06.001

OLIVEIRA, M.W. et al. Nitrogen fertilization in sugarcane nurses. Braz. J. Develop., v.6, n.1, p.2855-2860, 2020. doi: https://doi.org/10.34117/bjdv6n1-204

PEREIRA, V.H.; ROSA-MAGRI, M.M. Compatibilidade entre a bactéria diazotrófica Nitrospirillum amazonense e vinhaça: alternativa para a nutrição de cana-de-açúcar. Rev. Ciênc. Tecnol. Amb., 2021. https://doi.org/10.4322/rcta.2019.040

REICHARDT, K.; TIMM, L.C. Solo, planta e atmosfera: Conceito, processos e aplicações. Barueri: Manole, 2014.

REETZ, H.F. Fertilizantes e seu uso eficiente. São Paulo: ANDA, 2017.

ROCHA, I.T.M. et al. Altura, diâmetro e número de colmos de variedades de cana-de-açúcar não são influenciados por adubação potássica: Height, diameter and number of canes of sugarcane varieties are not influenced by potassium fertilization. Braz. J. Develop.. v.8, n.9, p.62125-62135, 2022. doi: https://doi.org/10.34117/bjdv8n9-191

SILVA, L.M.; BERTI, M.P.D.A.S. Manganese in soil and plants: a review. Sci. Electr. Arc., v.15, 2022. doi: https://doi.org/10.36560/15420221511

SRIVASTAVA, D. et al. General Introduction of Bio-Inputs Versus Chemical Inputs in Agriculture and Ill Effects. In: BIOFERTILIZERS AND BIOPESTICIDES IN SUSTAINABLE AGRICULTURE. Apple Academic, 2019. P.1-22.

SARITHA, M.; TOLLAMADUGU, N.P. The status of research and application of biofertilizers and biopesticides: global scenario. In: RECENT DEVELOPMENTS IN APPLIED MICROBIOLOGY AND BIOCHEMISTRY. Academic Press., 2019. doi: https://doi.org/10.1016/B978-0-12-816328-3.00015-5

TRIVEDI, M.H. et al. Field efficacy of bio-fertilizers and bio-inputs to improve wheat (Triticum aestivum) production under alkaline soil in Kachchh District of Gujarat. Int. J. Agricul. Environ. Biotechnol., v.13, n.4, p.431-437, 2020. doi: https://doi.org/10.30954/0974-1712.04.2020.19

SINGH, D.K. et al. Effect of bio-fertilizers on growth and yield of spinach (Beta vulgaris L.) cv. All Green. J. Agricul. Ecol., v.12, n.12, p.88-93, 2021. doi: http://doi.org/10.53911/JAE/2021.12208

VIO, S.A. et al. Multispecies bacterial bio-input: tracking and plant-growth-promoting effect on lettuce var. sagess. Plants, v.12, n.4, p.736, 2023. doi: https://doi.org/10.3390/plants12040736