Revista ARACÊ
ISSN: 2358-2472

CLEANER PRODUCTION: A SUSTAINABLE TOOL IN SOY TO REDUCE THE ENVIRONMENTAL FOOTPRINT OF CONVENTIONAL FERTILIZER USE

https://doi.org/10.56238/arev6n3-296

Submitted on: 10/21/2024 **Publication date:** 11/21/2024

Guilherme Celuppi[1], Cristiano Reschke Lajús[2], Francieli Dalcaton[3], Antônio Junior Dal Piva[4], Natalia Girardi[5], Aline Vanessa Sauer[6] and Caroline Olias[7]

ABSTRACT
For a more sustainable agriculture, new agricultural management must be adopted in order to maintain productivity and grain quality while respecting the environment. This study aims to investigate the feasibility of implementing rock dust-based biofertilizers in soybean crops, using the cleaner production program as a basis, aiming to reduce the environmental footprint of the use of conventional fertilizers. To this end, testing in the field this diversity of agrobiological products and managements, thus being exposed to climatic variation, pest and disease attack, in relation to the management adopted. The results showed that when contrasting the chemical and bioagricultural treatments, the latter presented significant results in relation to the variables number of active nodules in R1, NDVI V3, number of grains per pod, weight of one thousand grains, yield in kg/ha and SC/ha.

Keywords: Soybean, Agrobiological Management, Cleaner Production.

[1] Master's student in Technology and Innovation Management
Community University of the Chapecó Region
[2] Dr. in Plant Production
Community University of the Chapecó Region
[3] Dr. Food Engineering
Community University of the Chapecó Region
[4] Master in Technology and Innovation Management
Community University of the Chapecó Region
[5] Undergraduate student in Economic Sciences
Community University of the Chapecó Region
[6] Dr. in Plant Protection and Plant Pathology
North Paraná State University
[7] Master in Technology and Innovation Management
Community University of the Chapecó Region

INTRODUCTION

Due to rapid social and economic progress, there has been a significant increase in pollution and scarcity of natural resources, resulting in environmental impacts that have significantly impacted the planet. In view of this, there has been an increase in the population's concern and interest in issues related to the environment and its preservation, suggesting and implementing sustainable practices, ensuring that social and economic progress is in harmony with the environment (Cunha, 2023).

For a more sustainable agriculture, new agricultural management must be adopted in order to maintain productivity and grain quality while respecting the environment. With this, we must invest in research and new sources of fertilization, agrobiological treatments, thus leaving the conventional that season after season repeats itself, the same chemicals and fertilization with NPK, following an old cake recipe.

According to Alovisi et al. (2020), basalt powder can be considered as an alternative source of low-cost fertilizer and soil amendment. However, the low solubility of basalt powder indicates that this material cannot be used as the main source of nutrients for plants.

According to Polidoro et al. (2019), 79% of the total fertilizers consumed in the country are imported, which makes Brazilian agriculture very dependent on the foreign market and the price of the dollar. To reduce this dependence, which weighs on producers and on the country's trade balance, national agricultural research is developing and encouraging the use of alternative sources of nutrients.

The applicability of agrobiologicals, although still largely unknown by most producers, has become an advantageous alternative, both for financial reasons that become an attraction, and for biological reasons, which have a lower impact on the environment.

The idea of sustainability in agriculture advocates that the resources used have material and energy cycles that are as closed as possible in Agroecosystems and that producing using alternative inputs generated on the property itself not only offers healthier products, but also avoids environmental pollution, preserves natural resources and reduces dependence on inputs originating in oil (Moreira; Carmo, 2004; Silva et al., 2008). The use of these compounds in substitution or complement to mineral fertilization is gaining more and more importance from the economic point of view, the conservation of the physical and chemical properties of the soil and the reduction of the use of mineral fertilizers.

Revista ARACÊ
ISSN: 2358-2472

The use of the Cleaner Production Program can significantly reduce the environmental impacts generated by current conventional agricultural systems, creating a more sustainable mode of production, incorporating ecologically-based principles and technologies (Lima; Casalinho; Lima, 2020).

Cleaner Production is the continuous application of an integrated and preventive environmental strategy to processes, products and services, with the aim of increasing efficiency and reducing risks to humans and the environment (Unido/UNEP, 2005).

According to CNTL (2003), through Cleaner Production it is possible to observe the way a production process is being carried out and detect in which stages raw materials and resources are being wasted. Thus making it possible to improve the use of resources and reduce or even eliminate waste production. This transforms the practice of sustainable production into something essentially cost-effective and advantageous, serving as a crucial tool for complying with current environmental laws while driving sustainable progress.

This study aims to investigate the feasibility of implementing rock dust-based biofertilizers in soybean crops, based on the Cleaner Production program, aiming to reduce the environmental footprint of the use of conventional fertilizers. To this end, field testing agrobiological managements.

The present work aims to evaluate Cleaner Production in soybean crops as a sustainable alternative, aiming to reduce the environmental footprint of the use of conventional fertilizers.

THEORETICAL FOUNDATION

Soybean is a plant with photosynthetic metabolism type C3. Its morphology is characterized by a pivoting root, herbaceous stem and trifoliate leaf. It has an annual cycle, presenting great adaptive capacity to various ecosystems, which has led to the dissemination of its cultivation in the different agricultural environments of the world (Ferrari; Peace; Silva, 2015).

Among the essential nutrients in soybean crops, nitrogen (N) stands out, which is needed in greater quantity, because the grains are rich in proteins, with an average content of 6.5 % N. This, so used for the crop production process, comes from the soil (from the decomposition of organic matter and rocks), fertilizer and chemical fixation of atmospheric N2 (Lajús et al., 2023).

The amounts of mineral N from soil and chemical fixation are low. N as a source of plant fertilization, has a characteristic of rapid assimilation by plants, but it has a high cost, in addition to being lost by leaching processes and being highly polluting to the environment (Hungria et al., 2001).

This nutrient is an essential component for the formation of fundamental substances in the development of plants such as amino acids, proteins, DNA and RNA. Even if it is present in the atmosphere, it is not possible to metabolize them by plants, and symbiosis with bacteria is necessary for them to be absorbed by them (Caballero, 2015).

Biological nitrogen fixation (BNF) occurs naturally in legumes, where nitrogen that is readily available in the air is absorbed by microorganisms and becomes accessible to the plant in an assimilable form. For this process to happen, it is necessary to form a mutualistic symbiotic association between plants and bacteria called rhizobia (Pissáia, 2019).

When the symbiosis process occurs, bacteria of the genus Bradyrhizobium infect the soybean roots and form nodules, inside which an enzymatic complex is synthesized, called nitrogenase, causing the rupture of the triple bond between the N atoms that form the N2 molecule and use these atoms to produce two molecules of ammonia (NH3). that are supplied to plants to synthesize nitrogenous compounds (ALBINO; Campo, 2001).

In this context, soybeans, in turn, provide carbohydrates to bacteria. The greater the number of bacteria inoculated into the seed, the greater the competition with the bacterial populations already existing in the soil, resulting in the formation of nodules with the strains introduced by the inoculant (Marks, 2008).

Establishing a symbiotic relationship between plant and nitrogen-fixing bacteria is extremely important, significantly reducing the use of nitrogen by external source due to the ability of these microorganisms to provide a sufficient amount of the nutrient for the development of the plant and consequently achieving high yields (Pissáia, 2019).

BNF can provide from 65 to 160 kg N.ha-1 during soybean cultivation, which can represent up to 100% of the nitrogen required by this species (Zabludowicz; Reddy, 2007).

In agricultural production areas, the use of legumes such as soybeans, which play a very important role in the process of succession and crop rotation, mainly due to the symbiotic association with nitrogen-fixing bacteria. However, this important process has been suffering losses with the exacerbated use of agrochemicals, resulting in a reduction in the quality of soybeans produced in Brazil, especially with lower protein levels in the grains, which is a worrying aspect regardless of the purpose of production (Idalgo, 2019).

Revista ARACÊ
ISSN: 2358-2472

In order to improve the N fixation process, the inoculation of nitrogen-fixing microorganisms directly on the seed, by means of commercial inoculants is an alternative of great importance. The use of inoculation in soybean seeds presents better seedling development and nodulation, and the plant with good nodulation can be considered the one that at the flowering stage has between 15 and 30 nodules in the root (Santos, 2019).

The No-tillage System provides greater symbiotic quality in the soil with regard to the low rate of tillage and consequent maintenance of the system. The occurrence of nodular mass in soybean is higher in no-tillage soil when compared to conventional tillage, as well as a deeper distribution of nodules in the soil profile, in addition to more nodules (Voss, 1985).

Most of our mineral fertilizers and pesticides are imported for conventional cultivation, reducing this dependence and using organic fertilizers, biological pesticides become necessary and competitive, in addition to increasing the activity of the soil microbiota and making it more economically attractive with physiological and nutritional factors to the entire agricultural activity of soybeans (Lajús et al., 2023).

The way the soil is cultivated determines fundamental aspects intrinsic to the chemical, physical, and biological factors that favor the production of quality food and with volumes that meet the consumption demand for the survival of the world's population based on the planet's biodiversity (Silva, 2019).

The term Conventional System (CS) emerged with the so-called green revolution instituted in the 1960s, which had as its main objective the intensification of agricultural production and reduction of costs, seeking to expand access to food for the world population. Through 'technological packages' based on the use of improved seeds, agrochemicals, in addition to easy access to credit, rural producers were able to invest in technology on their property and in benefits from production costs. This intensification had a direct impact on consumers, since the price of food showed relevant drops (Bojanic, 2017).

Food production prior to the green revolution stood out for its low yield per area, in addition to the high strain of management, since machines were scarce and had low expansion potential. Over the decades, this system was improved and improved, until reaching the system known as NTS (No-Till System), considered fundamental to tropical countries such as Brazil. This system aims to minimize soil structural changes, losses due to leaching events, maintenance of edaphic microbiodiversity, maintain adequate soil vegetation cover, in addition to crop rotation and adequate management according to the

Revista ARACÊ
ISSN: 2358-2472

type of soil for the crop to be implanted, climatic and relief conditions of each region (Turetta et al., 2020).

The No-Till System, adopted in Brazil and other countries, aims to improve the qualities of the soil and consequently of the plants, and even with a short time of implementation, it is efficient in controlling water erosion (Salomão, 2020).

The conventional planting system evolved until it reached the so-called precision agriculture, which together with agricultural biotechnology, increasingly expandable in crops around the world, provides lower losses in fertilization and increasingly intensifies production, in addition to increasing productivity in productive areas. However, intensive systems, even if they significantly improve the use of areas, through sowing systems, may lead to the appearance of pests and diseases in soybean crops (Ferreira et al., 2019).

In addition, the intensified use of pesticides, based on the justification that food cannot be produced in sufficient quantity to supply the world market, which has high demand in quantity and affordable prices, being considered by many a "necessary evil" (Staback, 2020).

The excessive use of pesticides can lead to even irreversible problems for the fauna and flora around the crops and application areas. It can cause contamination of soil and groundwater, rivers and lakes, causing mortality in terrestrial and aquatic living beings, and lead to health problems for the human being who handles these products or who have indirect contact with them.

Agriculture plays a fundamental role in the development of society, but with the search to produce more food and under the pretext of meeting the global need, it created a hegemonic model of agricultural production, but finally increasing the use of inputs (De Lima; Biasoli; Borges, 2020). In opposition to this model, the agrobiological/bioagricultural management approach arises, which is based on a hybrid approach between chemical and biological management, aiming at sustainable production.

Much is currently said about the difference between 'food' and 'food', in this sense agrobiological techniques are gradually becoming present in the cultivation areas mainly in Family Production Units (UPF), aiming to add value to their products, serving a more select and demanding market and demanding for quality. The bioagricultural system aims to produce healthy food with alternative production methods to those used in conventional production systems. Using alternatives to reduce pesticides and in some cases even the eradication of agrochemicals, synthesized fertilizers and transgenic seeds, enhancing the production of quality food, in addition to reducing production costs (Lajús, et al., 2023).

Taking into account that the national agricultural chain is currently in vast expansion, as well as the soils that are used for agricultural purposes naturally have low fertility, Brazil has become a major importer of fertilizers. Approximately 79% of all chemical fertilizers used in Brazilian crops are imported, and the country becomes dependent on the foreign market. In order to reduce this dependence, alternatives using alternative fertilizers are increasingly researched and used in crops (Polidoro, 2017).

According to Normative Instruction (IN) No. 7, instituted on May 17, 1999, by the Ministry of Agriculture, Livestock and Supply (MAPA), organic production is based on the use of technologies in order to optimize natural and socioeconomic resources, abolish the use of pesticides, synthesized fertilizers and transgenic seeds, in addition to the use of radiation, in order to modify any and all stages of the production process, such as storage or consumption. It aims to preserve environmental and human health, ensures transparency in all phases of production and transformation (MAPA, 1999).

In this context, alternatives for pest control are widely used, as is the case of IPM (Integrated Pest Management), which is a strategy increasingly used in the agrobiological system. The selective and applied use when there is really a need (Economic Damage Level - NDE) in addition to the biological control of plants through natural enemies (insects, viruses, bacteria), and the use of pheromones (Avila, 2018).

The need to reduce the use of mineral fertilizers and environmental pollution has been discussed for several years. In the soybean crop associated with proper management, it has great economic, environmental and social interest. In this sense, the use of fertilization based on the use of organic waste is a viable alternative, as well as in increasing productivity, and reducing the cost of production of this crop (Vasques, 2018).

The use of rock dust or rock, although not a new concept, has been the subject of official research and company portfolios, especially after the Ministry of Agriculture, Livestock and Supply (MAPA), regulated the production, registration and trade of rock dust in agriculture, currently called "remineralizers", being the material of mineral origin that has only undergone reduction and size classification by mechanical processes and that alters soil fertility indexes, through the addition of macro and micronutrients to plants, as well as promoting the improvement of the physical, physicochemical properties and/or biological activity of the soil, in addition to the maximum allowed amounts of contaminants such as

Revista ARACÊ
ISSN: 2358-2472

Arsenic (As), Cadmium (Cd), Mercury (Hg) and Lead (Pb), in addition to serving as a comparative parameter in the prospection of new resources (Brazil, 2013).

According to Schmidt et al. (2019), the total replacement of soluble chemical fertilizers by the use of rock dust did not show any change in the chemical attributes of the soil, but rather an increase in positive effects on the production components, where a greater gain in pods with three grains was found in the treatments that received rock dust, when compared to the treatment without fertilization with rock dust.

In Brazil, the use of residues from common silicate rocks such as granite, basalt, gneisses and charnockites, has agricultural purposes that bring benefits to plants due to the nutrients existing in them, in addition to the low value for acquisition, due to the fact that it is rock mining waste (De Carvalho et al., 2013).

Rock dust is a by-product of crushing, which is considered a residue from the mining of some stones, usually basaltic, calcareous, silicate, granite, among others. Most of the time, this by-product is lost due to being processed in the open, which can lead to environmental problems in adjacent areas (Görgen et al., 2017). This by-product goes through an environmentally friendly process from solid to liquid form, giving rise to the product Liquid Foliar Fertilizer, or also called Biofertilizer, through the Expertise of THRIVE GESTÃO DE INOVAÇÕES, a company born in 2021, focused on creating innovative solutions for various areas of the agricultural sector (Thrive Gestão De Inovações, 2024).

METHODOLOGY

CHARACTERIZATION OF THE RESEARCH ENVIRONMENT

The present work was implemented in an area of annual planting for soybean cultivation, belonging to Mr. Edson Luiz Celuppi. The property is located on the Maidana Line, in the interior of the Municipality of Águas de Chapecó, located in the west of the State of Santa Catarina. It has an altitude of 345 meters above sea level, with latitude coordinates 26°59'23"S and longitude 52°55'00"W. Location that is represented in Image 1.

Revista ARACÊ
ISSN: 2358-2472

Image 1 - Experiment site (Águas de Chapecó/SC – Harvest, 2023/2024)

Source: Google Earth (2023).

According to the municipality of Águas de Chapecó (2023), the climate of the municipality is classified as humid Mesotherm, the average annual temperature is 17°C, with a minimum reaching 5°C and a maximum of 36°C. Annual rainfall occurs approximately between 1000mm and 2000mm per year.

According to the Brazilian Soil Classification System, the soil of the region is classified as a typical Dystrophic Red Latosol (EMBRAPA, 2013). They are mineral, non-hydromorphic, deep soils (usually greater than 2 m), with silt content of less than 20% and clay ranging between 15% and 80%. They are soils with high water permeability, and can be worked in a wide range of humidity.

STRATEGY AND RESEARCH DESIGN

In order to ensure the recognition of a research, having relevant and solidified potential, both for the academy and for society, it must demonstrate that it was rigorously developed and that it is subject to debate and verification. In this sense, the methodology for the research to be developed must be robust in order to be successful in conducting a study (Lacerda, 2013).

Revista ARACÊ
ISSN: 2358-2472

The use of common sense, as well as science, are expressions of the same need, that is, it is based on the need to understand the world, aiming to improve people's quality of life, associated with the sustainable development of the system (Assis; Alves, 2002).

As described by Gil (2008), the research design regarding the approach, focus and procedure were:

- ✓ Regarding the approach: It consists of a quantitative research, as it considers that everything is quantifiable, which means translating numbers into information that has been classified and analyzed;
- ✓ Regarding the focus: It consists of an explanatory research, by identifying the factors that determine phenomena, explaining the why of things;
- ✓ Regarding the procedures: It consists of an experimental research, which determines an object of study, variables that influence are selected, the forms of control and observation of the effects that the variables produce on the object are defined.

DATA COLLECTION TECHNIQUES

Laboratory analyses were carried out (Image 02) to define the best method of extraction and solubilization of nutrients found in basalt rock dust, as well as tests were carried out in a controlled environment, in order to characterize and qualify the product, thus defining a 'dosage' based on agronomic statements.

Image 02 - Variables analyzed and methodology

Ensaio	Método
Nitrogênio Total	MAPA
Fósforo Total	MAPA
Potássio (HNO3 + HClO4)	MAPA
Cálcio (HNO3 + HClO4)	MAPA
Magnésio (HNO3 + HClO4)	MAPA
Enxofre (sol. em Água)	MAPA
Boro	MAPA
Cobre (HNO3 + HClO4)	MAPA
Manganês (HNO3 + HClO4)	MAPA
Ferro (HNO3 + HClO4)	MAPA
Zinco (HNO3 + HClO4)	MAPA
Alumínio (HNO3 + HClO4)	MAPA
Sódio (HNO3 + HClO4)	MAPA
Matéria Orgânica	MP FERT 01
Umidade (65 °C)	MAPA
Cinzas	Cálculo
Cobalto (HNO3 + HClO4)	MAPA
Molibdênio (HNO3 + HClO4)	MAPA

Thrive Gestao de Inovacoes Ltda
R Menna Barreto, 324 Letra E
São Cristovão- Chapecó/SC
89803-280

Relatório de Ensaio

O.S.: 188069

IBRA Fertilizantes e Corretivos

Legenda:
LQ = Limite de Quantificação
C = Ensaio realizado em campo
V.M.P. = Valor Máximo Permitido

Métodos:
Titulometria = MAPA
Gravimetria = MAPA
Espectrometria de Emissão Atômica = MAPA
Espectrometria de Absorção Atômica = MAPA
Espectrometria de Absorção Atômica = MAPA
Gravimetria = MAPA
Espectrofotometria = MAPA
Espectrometria de Absorção Atômica = MAPA
Espectrometria de Absorção Atômica = MAPA
Espectrometria de Absorção Atômica = MAPA
Espectrometria de Absorção Atômica = MAPA
Espectrometria de Absorção Atômica = MAPA
Espectrometria de Emissão Atômica = MAPA
Gravimetria = MP FERT 01
Perda por Secagem = MAPA
Cálculo = Cálculo
Espectrometria de Absorção Atômica = MAPA
Espectrometria de Absorção Atômica = MAPA

Observações:
O laboratório não é responsável pela amostragem.
Este(s) resultado(s) refere(m)-se somente ao(s) item(s) ensaiado(s)
Este relatório de ensaio somente pode ser reproduzido na sua totalidade e sem alterações. A reprodução parcial requer aprovação escrita do Laboratório

IBRA®
INSTITUTO BRASILEIRO DE ANÁLISES

Carlos Eduardo Prieto
Gerente Tecnico - CRQ 04261966

LABORATÓRIO SEDE: Rua Amazonas, 220 - Jd. Nova Veneza, 13177-060 - Sumaré - SP - PABX +55 (19) 3832.3679 - laboratorio@ibra.com.br - www.ibra.com.br

Source: IBRA (2022).

Revista ARACÊ
ISSN: 2358-2472

Stage 1 consisted of conducting laboratory analyses of the base product for future research, this product is composed of the solubilization of rock dust in a solution based on distilled water and an organic acid consisting of the dilution of a fraction of the "filler" rock powder, in the acid solution, through agitation for a XX-XX time at temperature YY-YY. Where later this mixture remains in a rest period for approximately one hour, where after that the liquid and solids from the mixture are separated. The basalt powder 'filler' came from crushing waste from the company Concrexap Serviços de Concretagem, located in Chapecó-SC.

The analyses were based on the evaluation of pH, density, solubility, and the nutritional contents of this product. In order to get to know him in depth for later decision-making. Stage 2 consisted of the production of the biofertilizer itself, mixing the base product, along with the addition of a formulation of vegetable amino acids (soybean, corn and sugarcane yeast bland), as well as an organic stabilizer.

The entire process is without the interference of any inorganic chemical agent. Through a thermal extraction process, oxide nutrients are obtained, after which the doses of amino acids and seaweed are mixed, the solution oxidizes, for a certain time in a centrifugal and thermal process (Thrive Innovation Management, 2024).

It was at this moment that the product once studied was formulated in accordance with the Normative Instructions established by the Ministry of Agriculture, Livestock and Supply – MAPA. Carrying out the necessary analyses, as well as choosing the target crop for the use of the product, in addition to stipulating the appropriate dosage it needs.

And finally, stage 3, which was the definition of the ideal phase of the soybean crop, to use the product via foliar, applying it in strategic periods, and later carrying out the necessary analyzes (field and laboratory). After this data collection, the data went through the Analysis of Variance, in order to conclude the technical efficiency of the final product. The basaltic rock powder as already described came from the company Concrexap located in Chapecó-SC, this 'filler' powder is considered a residue of the company's main activity which is crushing, as shown in Photo 01, while Photo 02 demonstrates how the process was carried out obtaining sampling, as well as extracting nutrients.

Revista ARACÊ
ISSN: 2358-2472

Photo 01 - Place of obtaining basalt dust samples (Chapecó, SC – 2023)

Source: Concrexap Concreting Services (2023).

Photo 02 - Formation of samples and result obtained after the extraction process

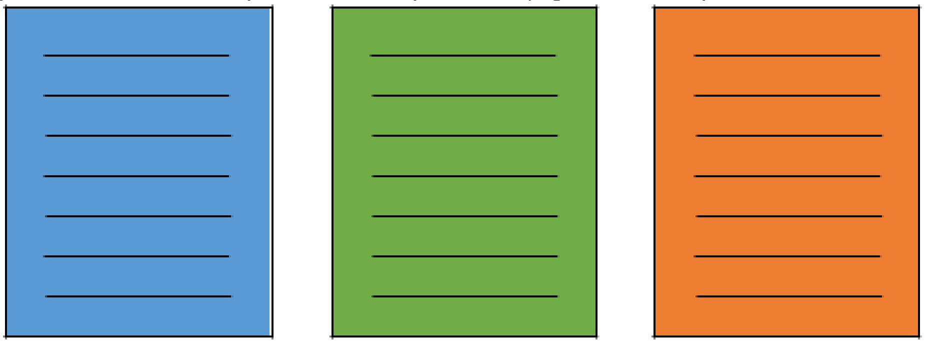
Source: Thrive Innovation Management (2023).

Experimental Design and Treatments

The DIC (Entirely Randomized Design) was used, with 3 treatments and 7 replications, totaling 21 plots (Image 03). The treatments used were:

Revista ARACÊ
ISSN: 2358-2472

Image 03 - Sketch of the plots of the experiment (Águas de Chapecó, 2023/2024 harvest)



* T1: Witness
* T2: Biological (Biofertilizer)
* T3: Chemical (Farm Treatment)

Source: prepared by the author, 2024.

Cultural Treatments

The implementation of the experiment was carried out on wheat straw. Sowing took place on November 7, 2023, with a spacing of 50cm between rows, with a population of 12 plants per linear meter, totaling a final population of 240 thousand plants per hectare. With this, sowing was carried out, deposition of the fertilizer and seed in the planting furrow.

Chemical fertilizer was used at the dosage of 210 kg/ha of the formula 4-24-12, (NPK), fertilization was carried out via planting row, with the aid of a seeder, as shown in Photo 03. The cultivar sown at the experimental site was Brasmax Vênus, with direct chemical treatment from the UBS.

Photo 03 - Sowing of the plots of the experiment (Águas de Chapecó, 2023/2024 harvest)

Source: prepared by the author.

Sowing took place on November 7, 2023, with a spacing of 50cm between rows, with a population of 12 plants per linear meter, totaling a final population of 240 thousand plants per hectare. With this, sowing was carried out, deposition of the fertilizer and seed in the planting furrow.

Revista ARACÊ
ISSN: 2358-2472

The cultivar sown at the experimental site was Brasmax Vênus, with direct chemical treatment from the UBS. It is resistant to diseases such as Stem Canker, Bacterial Pustule and Phytophthora Root Rot.

Biofertilizer is composed of nutrient oxides + amino acid blend + specific seaweed. The entire process is without the interference of any inorganic chemical agent. Through a thermal extraction process, oxide nutrients are obtained, after which the doses of amino acids and seaweed are mixed, the solution oxidizes, for a certain time in a centrifugal and thermal process (Thrive Innovation Management, 2024).

Phytosanitary treatments and Biofertilizer were applied according to the needs of the crop, taking into account the preventive management of the crop.

Response Variables

Vegetation Index (NDVI)

The Normalized Difference Vegetation Index (NDVI) is the most well-known vegetation index among several spectral vegetation indices. NDVI measures the difference and provides a measure of the density and condition of the vegetation, widely used to better verify and evaluate the results, especially up to the growth phase of the plants. Plants during the photosynthesis process emit radiation and the equipment has the ability to collect the reflectance of the leaves, due to the thick layer on the surface of the leaf, and especially the red light and more collected by the device (Lajús et al., 2023).

NDVI reading was performed in stages V3 and R1 (Photos 4 and 5) with the aid of a GreenSeeker® portable device.

Revista ARACÊ
ISSN: 2358-2472

Photo 04 - First evaluation of the experiment (Águas de Chapecó, 2023/2024 harvest)

Source: prepared by the author, 2024.

Photo 05 - NDVI (GreenSeeker®) reading of the experiment (Águas de Chapecó, 2023/2024 harvest)

Source: prepared by the author.

Sowing took place on November 7, 2023, with a spacing of 50cm between rows, with a population of 12 plants per linear meter, totaling a final population of 240 thousand plants per hectare. With this, sowing was carried out, deposition of the fertilizer and seed in the planting furrow.

Revista
ARACÊ
ISSN: 2358-2472

The cultivar sown at the experimental site was Brasmax Vênus, with direct chemical treatment from the UBS. It is resistant to diseases such as Stem Canker, Bacterial Pustule and Phytophthora Root Rot.

Biofertilizer is composed of nutrient oxides + amino acid blend + specific seaweed. The entire process is without the interference of any inorganic chemical agent. Through a thermal extraction process, oxide nutrients are obtained, after which the doses of amino acids and seaweed are mixed, the solution oxidizes, for a certain time in a centrifugal and thermal process (Thrive Innovation Management, 2024).

Phytosanitary treatments and Biofertilizer were applied according to the needs of the crop, taking into account the preventive management of the crop.

Chlorophyll Concentration Index (SPAD)

The SPAD (Photo 6) measures, as an index of green or relative concentration of chlorophyll, the difference in light transmitted in the leaf by means of two detectors at the lengths of 650 μm and 940 μm. Light transmitted at 650 μm (red light) is associated with the wavelengths of chlorophylls a and b (645 μm and 663 μm, respectively) (Minolta et al., 1989).

Photo 06 - SPAD reading of the experiment (Águas de Chapecó, 2023/2024 harvest

Source: prepared by the author, 2024.

Income

The harvest was carried out manually on March 15, 2024. 7 plots were collected within each treatment, having been packed in identified bags (Photo 7), so that yield data could be collected later. After the measurements were taken, the plants were manually

Revista ARACÊ
ISSN: 2358-2472

threshed, so that the number of pods per plant and grains per pod could be counted later (Photo 8). After accounting for the number of grains within each plot, a thousand grains were weighed (Photo 9) and moisture extracted from the harvested grains (Photo 10) (Brasil, 2009).

Photo 07 - Harvesting of the plots of the experiment (Águas de Chapecó, 2023/2024 harvest)

Source: prepared by the author, 2024.

Photo 08 - Number of pods per plant and grains per pod of the experiment (Águas de Chapecó, 2023/2024 harvest)

Source: prepared by the author, 2024.

Revista ARACÊ
ISSN: 2358-2472

Photo 09 - Weight of a thousand grains of the experiment (Águas de Chapecó, 2023/2024 harvest)

Source: prepared by the author.

Photo 10 - Extraction of moisture from the grains of the experiment (Águas de Chapecó, 2023/2024 harvest)

Source: prepared by the author, 2024.

Cleaner Production

During the course of the research, the P+L methodology will be implemented continuously applied to prevent losses, allowing the increase in efficiency of the use of

Revista ARACÊ
ISSN: 2358-2472

natural resources, minimizing waste, tending to reduce costs, waste of raw materials and energy, thus reducing environmental risks.

TECHNIQUES FOR DATA ANALYSIS AND INTERPRETATION

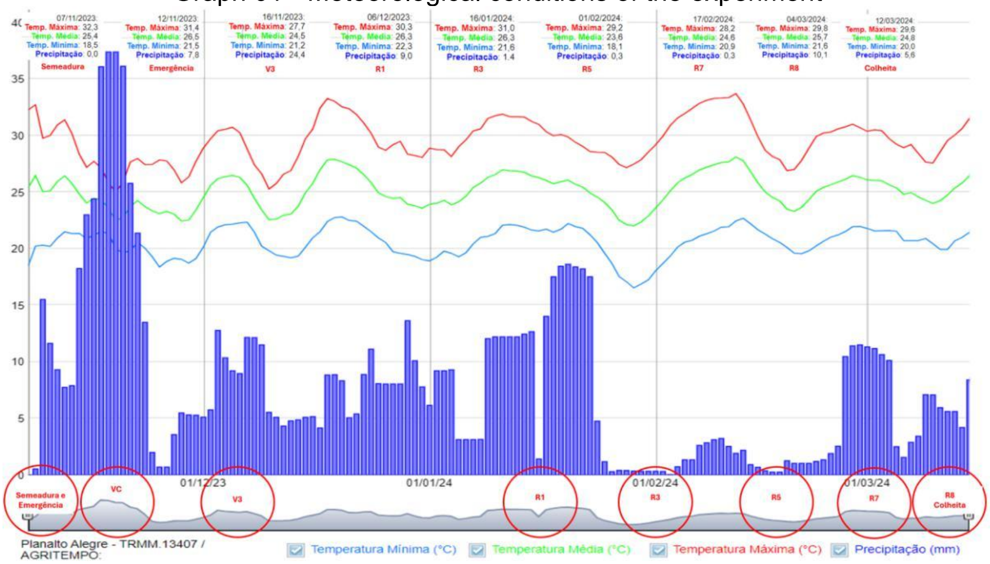
The collected data were submitted to Analysis of Variance (ANOVA) by the F test ($P \leq 0.05$). The comparison of the means was performed using Tukey's test ($P \leq 0.05$). The statistical software called SISVAR was used for the graphical demonstration of the results (Ferreira, 2011).

RESULTS

CLIMATIC CONDITIONS OF THE EXPERIMENT

The climatic conditions of the experiment (Graph 01) were monitored by the Planalto Alegre Agrometeorological Station through the Agritempo website (2024), with a correction of 1ºC according to the altitude of the research site.

Graph 01 - Meteorological conditions of the experiment



Source: Agritempo (2024).

In primordial stages for a good yield of the soybean crop, such as in the emergence of the vegetative stages V3 with the second trifoliate leaf fully developed, third node and V5 with the fourth trifoliate leaf completely expanded, fifth node, as well as in the reproductive stages, such as R1 at the beginning of flowering, the first flower open at any node of the stem, R3 at the beginning of pod formation, 5mm long, R5 at the beginning of grain filling at 3mm length, water availability is essential for good plant and fruit formation (Celuppi et

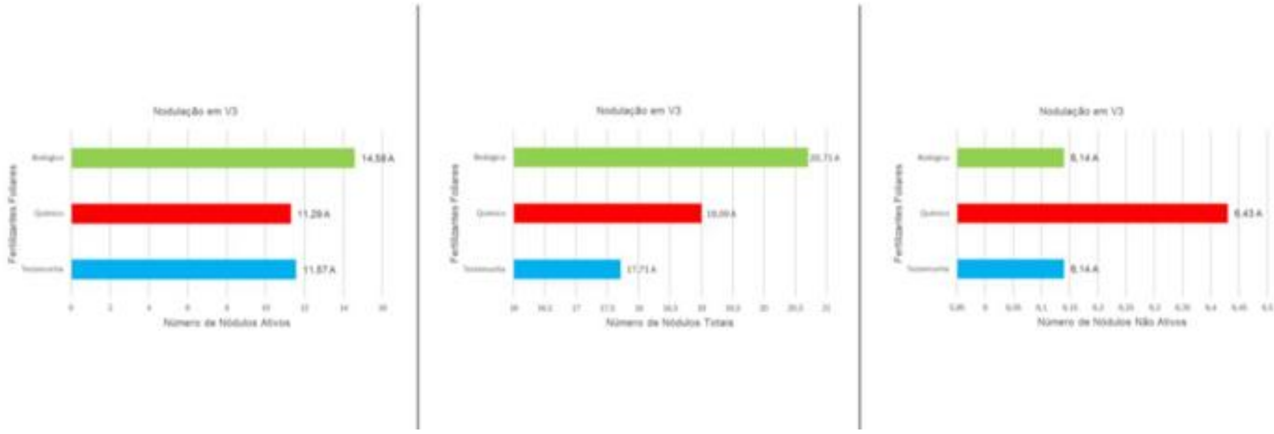
Revista ARACÊ
ISSN: 2358-2472

al., 2023). As observed in Graph 1, the rain was present in the stages of grain formation, remaining even with lower volumes in the other phases, benefiting the development of the crop.

NODULATION, NDVI AND SPAD

ANOVA did not reveal a significant effect (P>0.05) of the treatments in relation to the response variables: number of active nodules, number of inactive nodules, and number of total nodules in V3 (Graph 02).

Graph 02 - Nodulation in V3



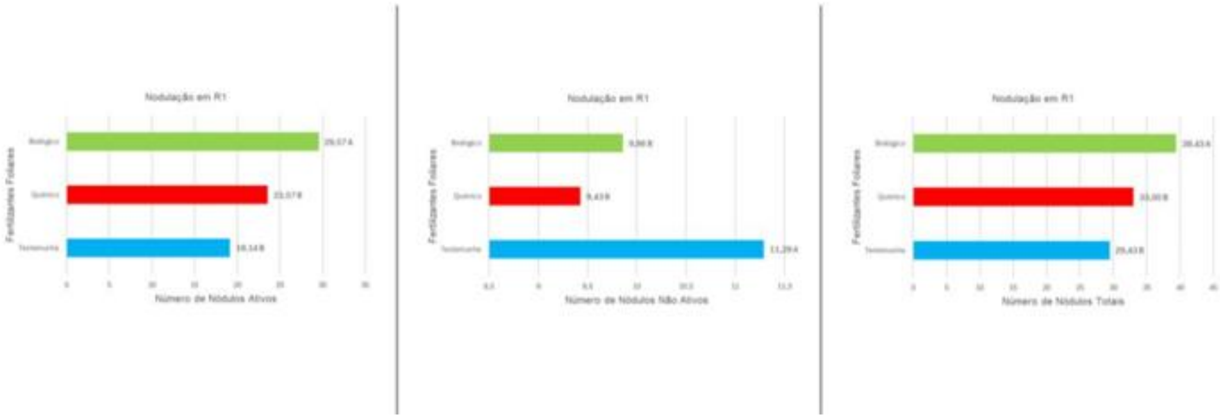
Means not followed by the same letter differ significantly (P≤0.05) by Tukey's test.
Source: prepared by the author, 2024.

According to Graph 02, it can be seen that there was no cause and effect relationship between the treatment variable and the number of active nodules, number of inactive nodules and number of total nodules in V3, that is, among the different treatments, these variables did not differ significantly.

ANOVA revealed a significant effect (P≤0.05) of the treatments in relation to the response variables: number of active nodules, number of inactive nodules, and number of total nodules in R1 (Graph 03).

Revista ARACÊ
ISSN: 2358-2472

Graph 03 - Nodulation in R1

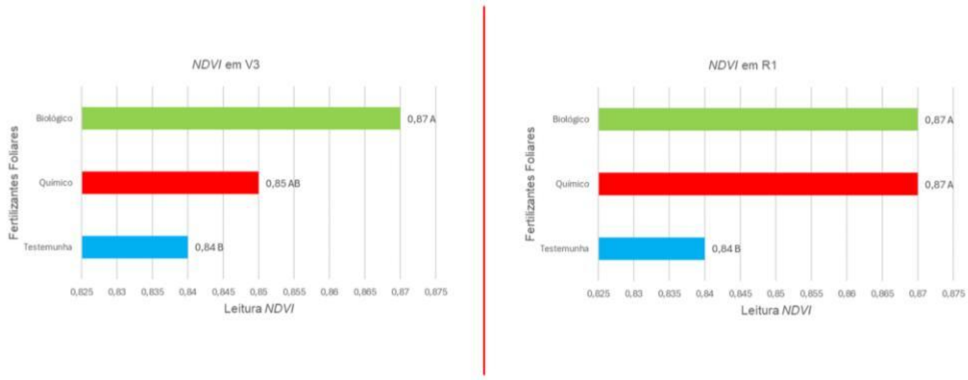


Means not followed by the same letter differ significantly (P≤0.05) by Tukey's test.
Source: prepared by the author.

Graph 03 shows a cause and effect relationship between the variable treatments and the variables number of active nodules, number of inactive nodules and number of total nodules in R1, i.e., among the different treatments these variables differed significantly, with the portion treated with bioagricultural fertilizers having the highest number of active nodules.

ANOVA revealed a significant effect (P≤0.05) of the treatments in relation to the NDVI response variables in V3 and R1 (Graph 04), i.e., at least one treatment differed from the others in relation to the response variable.

Graph 04 - NDVI in V3 and R1



Means not followed by the same letter differ significantly (P≤0.05) by Tukey's test.
Source: prepared by the author.

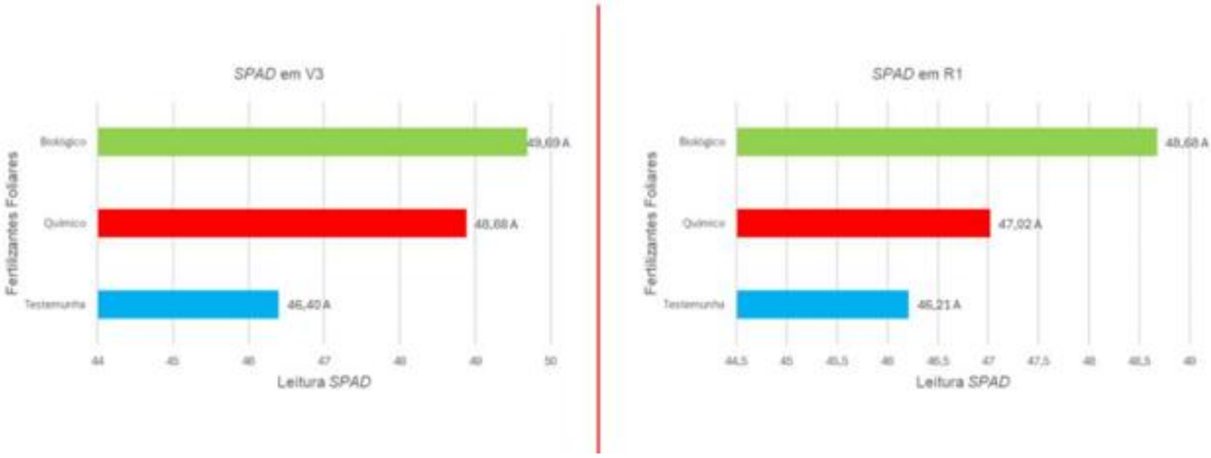
Graph 04 shows a cause and effect relationship between the treatments variable and the NDVI response variable in V3, i.e., among the different treatments this variable differed significantly, the portion treated with bioagricultural fertilizers presented a superior result to

Revista ARACÊ
ISSN: 2358-2472

the other treatments. In R1, this response variable presented the same result when compared to chemical fertilizers.

ANOVA did not reveal a significant effect (P>0.05) of the treatments in relation to the SPAD response variables in V3 and R1 (Graph 05).

Graph 05 - SPAD in V3 and R1



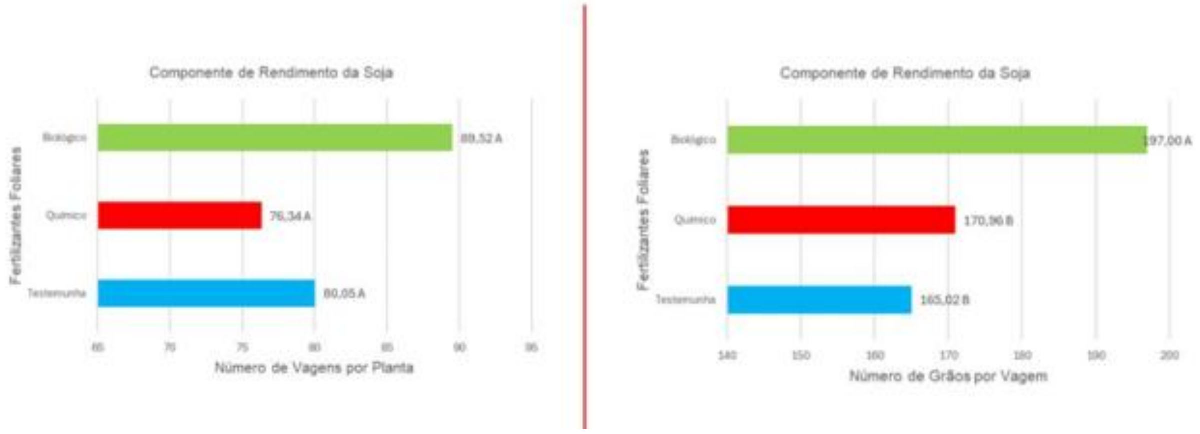
Means not followed by the same letter differ significantly (P≤0.05) by Tukey's test.
Source: prepared by the author.

According to Graph 05, it can be seen that there was no cause and effect relationship between the treatments variable and the SPAD variables in V3 and R1, that is, among the different treatments, these variables did not differ significantly. Thus, there is no mathematical model that explains the relationship between the different treatments and the response variable.

YIELD COMPONENTS

ANOVA did not reveal a significant effect (P>0.05) of the treatments in relation to the response variable number of pods per plant and revealed a significant effect (P≤0.05) of the treatments in relation to the response variable number of grains per pod (Graph 06).

Graph 06 - Number of pods per plant and number of grains per soybean pod

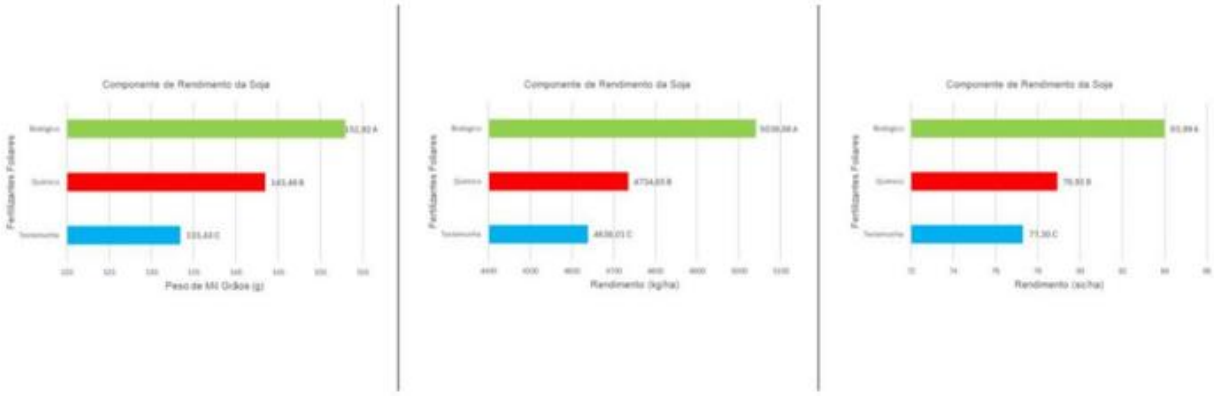


Means not followed by the same letter differ significantly (P≤0.05) by Tukey's test.
Source: prepared by the author.

According to Graph 06, it can be seen that there was no cause and effect relationship between the treatment variable and the response variable number of pods per plant, that is, between the different treatments these variables did not differ significantly. Thus, there is no mathematical model that explains the relationship between the different treatments and the response variable. However, it demonstrated a cause and effect relationship between the treatments in relation to the response variable number of grains per pod, that is, among the different treatments this variable differed significantly, the plot treated with bioagricultural fertilizers presented a higher yield than the other treatments.

ANOVA revealed a significant effect (P≤0.05) of the treatments in relation to the response variables weight of a thousand grains, yield in kg/ha and sc/ha (Graph 07).

Graph 07 - Weight of a thousand grains, yield in kg/ha and sc/ha of soybeans



Means not followed by the same letter differ significantly (P≤0.05) by Tukey's test.
Source: prepared by the author.

Revista ARACÊ
ISSN: 2358-2472

Regarding the response variables weight of a thousand grains, yield in kg/ha and sc/ha, both presented a cause and effect relationship with the different treatments, that is, among the different treatments this variable differed significantly, the portion treated with bioagricultural fertilizers presented higher yield than the others.

CONCLUSION

For a more sustainable agriculture, it is necessary to adopt new agricultural techniques to ensure the maintenance of productivity and grain quality, respecting the environment.

The study demonstrated the applicability of agrobiologicals, although still largely unknown by most producers, as an advantageous alternative, both for financial reasons that become an attraction, and for biological reasons, which have a lower impact on the environment.

The results showed that when contrasted with the chemical treatments, the biofertilizer presented significant results in relation to the variables number of active nodules in R1, NDVI V3, number of grains per pod, weight of one thousand grains, yield in kg/ha and SC/ha. Validating the product as a sustainable alternative for Cleaner Production, which makes it possible to reduce the environmental impacts caused by the excessive use of conventional fertilizers.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Albino, U. B., & Campo, R. J. (2001). Efeito de fontes e doses de molibdênio na sobrevivência do Bradyrhizobium e na fixação biológica de nitrogênio em soja. Pesquisa Agropecuária Brasileira, 36(3), 527-534.

2. Alovisi, A. M., et al. (2020). Rochagem como alternativa sustentável para a fertilização de solo. Revista Gestão & Sustentabilidade Ambiental.

3. Assis, O. B. G., & Alves, H. C. (2002). Metodologia mínima para a produção de filmes comestíveis de quitosana e avaliação preliminar de seu uso como revestimento protetor em maçãs cortadas. Embrapa Instrumentação - Comunicado Técnico (INFOTECA-E).

4. Ávila, C. J. (2018). Manejo integrado de pragas (MIP) na cultura da soja: Um estudo de caso com benefícios econômicos e ambientais. Embrapa Agropecuária Oeste. Retrieved June 26, 2024, from https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1098927

5. Blanco, I. B. (2015). Adubação da cultura da soja com dejetos de suínos e cama de aves. Unioeste, Cascavel.

6. Bojanic, A. (n.d.). A segurança alimentar, a produção agrícola e o desenvolvimento sustentável. Brazilian Agricultural Research Corporation – Embrapa. Retrieved June 23, 2024, from https://www.embrapa.br/-/olhares-2030-alanbojanic#:~:text=Est%C3%A1vamos%20diante%20da%20chamada%20Revolu%C3%A7%C3%A3o,das%20colheitas%20e%20suprimentos%20alimentares.&text=Al%C3%A9m%20disso%2C%20podemos%20dizer%20que,considerar%20aspectos%20sociais%20e%20ambientais

7. Brasil. (2013). Lei nº 12.890, de 10 de dezembro de 2013. Altera a Lei nº 6.894, de 16 de dezembro de 1980, para incluir os remineralizadores como uma categoria de insumo destinado à agricultura, e dá outras providências. Retrieved June 26, 2024, from http://www.planalto.gov.br

8. Caballero, S. S. U. (2015). O nitrogênio e as plantas. Embrapa Soja. Retrieved June 23, 2024, from http://www.agencia.cnptia.embrapa.br/gestor/canadeacucar/arvore/CONTAG01_31_711200516717.html

9. Celuppi, G., et al. (2023). Propriedades qualitativas e quantitativas da soja submetida a aplicação de leite de pedra. In Tecnologia e gestão da inovação em sistemas de produção sustentáveis. Campina Grande: EPTEC.

10. Centro Nacional de Tecnologias Limpas. (2003). Retrieved June 23, 2024, from http://www.cntl.com.br/

11. Cunha, T. F. da S., Pires, M. L., & Paula, L. D. R. de. (2023). Produção mais limpa: Uma ferramenta sustentável. Paramétrica, 15(1). Retrieved November 1, 2024, from https://www.periodicos.famig.edu.br/index.php/parametrica/article/view/407

Revista ARACÊ
ISSN: 2358-2472

12. De Carvalho, A. M. X., et al. (2013). Plantas, micorrizas e microbiota do solo na disponibilização de nutrientes de pós de rocha. In II Congresso Brasileiro de Rochagem (p. 13).

13. Embrapa. Centro Nacional de Pesquisa de Solos. (2013). Sistema brasileiro de classificação de solos (3rd ed.). Brasília: Embrapa Produção de Informação; Rio de Janeiro.

14. Ferrari, E., Paz, A., & Silva, A. C. (2015). Deficit hídrico no metabolismo da soja em semeaduras antecipadas no Mato Grosso. Nativa, 3(1), 67-77.

15. Ferreira, D. F. (2011). Sisvar: Um sistema computacional de análise estatística. Ciência e Agrotecnologia, 35(6), 1039-1042.

16. Ferreira, E. A., et al. (2019). Fitossociologia de plantas daninhas na cultura do milho submetida à aplicação de doses de nitrogênio. Revista de Agricultura Neotropical, 6(2), 109-116.

17. Gil, A. C. (2008). Métodos e técnicas de pesquisa social (6th ed.). São Paulo: Atlas.

18. Görgen, C. A., et al. (2017). Modificações químicas em solo arenoso remineralizado com rochas alcalinas cultivado com soja. In Congresso Brasileiro de Geoquímica, 16., Armação dos Búzios. Anais... Rio de Janeiro: Sociedade Brasileira de Geoquímica.

19. Hungria, M., et al. (2001). Fixação biológica do nitrogênio na cultura da soja. Londrina: Embrapa Soja.

20. Idalgo, T. D. N., et al. (2019). Qualidade nutricional do grão e parâmetros de produção de soja em sistema orgânico e convencional [Doctoral dissertation, Universidade Federal de Santa Maria].

21. Lacerda, D. P., et al. (2013). Design Science Research: Método de pesquisa para a engenharia de produção. Gestão & Produção, 20(4), 741-761.

22. Lajús, C. R., et al. (2023). Tecnologia e gestão da inovação em sistemas de produção sustentáveis. Campina Grande: EPTEC.

23. Lima, E. P. P., Casalinho, H. D., & Lima, A. C. R. de. (2020). Produção mais limpa como ferramenta na construção de agroecossistema de base ecológica em propriedade agrícola familiar. Revista Thema, 17(4), 883-898.

24. Lima Miranda, I., Biasoli, O. L., & Borges, L. P. C. (2020). Boas práticas agrícolas em propriedades agroecológicas. In Anais... Sergipe.

25. Marks, B. B. (2008). Avaliação da sobrevivência de bradirrizóbios em sementes de soja tratadas com fungicidas, protetor celular “Power” e o inoculante “Nitragin Optimize”. Porto Alegre.

26. Ministério da Pecuária e Abastecimento. (2017). Instrução Normativa nº 7, de 17 de maio de 1999.