RGSA – Revista de Gestão Social e Ambiental
ISSN: 1981-982X
Submission date: 6/27/2025
Acceptance date: 8/29/2025
DOI: https://doi.org/10.24857/rgsa.v19n9-086
Organization: Interinstitutional Scientific Committee
Chief Editor: Ana Carolina Messias de Souza Ferreira da Costa
Assessment: Double Blind Review pelo SEER/OJS

ALTERNATIVE SUBSTRATES: A PROPOSAL FOR VIABILITY AND SUSTAINABILITY IN CORIANDER CULTIVATION

Késia Laís Neri Coelho Brauno[1]
Letícia Karen Oliveira Carvalho[2]
Adriane Pereira Barros [3]
Priscila Gonçalves Figueiredo de Sousa[4]
Railson Rosal de Sousa[5]
Rebeca Dorneles de Moura[6]

ABSTRACT

Objective: The objective of this study is to evaluate the germination, growth, and development of coriander (Coriandrum sativum L.) in different types of alternative substrates to determine their technical and economic feasibility for small producers.

Theoretical Framework: The premise is that the ideal balance between the physical and chemical properties of the substrate is essential for the rapid establishment and high productivity of the crop, which has a short cycle and socioeconomic relevance. The use of alternative substrates aligns with the Sustainable Development Goals (SDGs) of the 2030 Agenda, promoting sustainability, circular economy, and the overcoming of economic barriers associated with the use of non-renewable inputs.

Method: The experiment was conducted in randomized blocks, comparing five substrate formulations (T1 – Control and T2 to T5 – Alternative) with four replications. The sowing and germination counting methodology followed official standards (Brazil, 2009). The key measurement parameters were the germination percentage and the accumulation of fresh mass in the aerial and root parts.

Results and Discussion: It was observed that all alternative substrates (T2 to T5) significantly outperformed the control, with treatments T4 and T5 being the most effective, showing higher germination rates and biomass accumulation. These results are attributed to optimized porosity and greater phosphorus (P) availability, which ensure ideal conditions in the root zone and greater nutritional efficiency.

Research Implications: This study provides a technical evaluation of regional substrates for coriander, confirming their feasibility and profitability, ensuring that agronomic advancement translates into sustainability for Family Farming. Future research is suggested with detailed economic analysis and measurement of the physical properties of the substrates, correlating them directly with agronomic performance.

Originality/Value: This study enhances regional resources as viable and sustainable alternatives to conventional commercial substrates, expanding opportunities for small producers and strengthening practices aligned with sustainability and the SDGs.

Keywords: Agroecology, Agricultural Residues, Cropping Systems, Horticulture, Low-Cost Inputs.

[1] Instituto Federal de Educação, Ciência e Tecnologia do Tocantins (IFTO), Araguatins, Tocantins, Brazil.
E-mail: keshneri@gmail.com
[2] Universidade Estadual do Norte Fluminense (UENF), Axixá do Tocantins, Tocantins, Brazil.
E-mail: kaarenleticia32@gmail.com
[3] Instituto Federal de Educação, Ciência e Tecnologia do Tocantins (IFTO), Axixá do Tocantins, Tocantins, Brazil.
E-mail: barros.adriane22@gmail.com
[4] Universidade Estadual do Norte Fluminense (UENF), Axixá do Tocantins, Tocantins, Brazil.
E-mail: priscila.gf@unitins.br
[5] Instituto Federal de Educação, Ciência e Tecnologia do Tocantins (IFTO), Araguatins, Tocantins, Brazil.
E-mail: railson78@gmail.com
[6] Universidade Estadual do Norte Fluminense (UENF), Araguatins, Tocantins, Brazil.
E-mail: dornelesrebeca@gmail.com

SUBSTRATOS ALTERNATIVOS: UMA PROPOSTA DE VIABILIDADE E SUSTENTABILIDADE NO CULTIVO DO COENTRO

RESUMO

Objetivo: O objetivo deste estudo é avaliar a germinação, crescimento e desenvolvimento do coentro (*Coriandrum sativum* L.) em diferentes tipos de substratos alternativos para determinar sua viabilidade técnica e econômica para pequenos produtores.

Referencial Teórico: A premissa é que o equilíbrio ideal entre as propriedades físicas e químicas do substrato são imprescindíveis para o rápido estabelecimento e alta produtividade da cultura, que têm ciclo curto e relevância socioeconômica. A utilização de substratos alternativos alinha-se aos Objetivos de Desenvolvimento Sustentável (ODS) da Agenda 2030, promovendo a sustentabilidade, a economia circular e a superação de barreiras econômicas relacionadas ao uso de insumos não renováveis.

Método: O experimento foi conduzido em blocos casualizados, comparando cinco formulações de substratos (T1 – Testemunha e T2 a T5 Alternativos) com quatro repetições. A metodologia de semeadura e contagem de germinação seguiu as normas oficiais (Brasil, 2009). Os parâmetros chave de medição foram o percentual de germinação e o acúmulo de massa fresca da parte aérea e radicular.

Resultados e Discussão: Observou-se que todas os substratos alternativos (T2 a T5) superaram significativamente a testemunha, sendo os tratamentos T4 e T5 os mais eficazes, com maiores índices de germinação e acúmulo de biomassa. Tais resultados se devem à otimização da porosidade e à maior disponibilidade de Fósforo (P), o que garante condições ideais na zona radicular e maior eficiência nutricional.

Implicações da Pesquisa: Esta pesquisa fornece a avaliação técnica de substratos regionais para o coentro, comprovando sua viabilidade e rentabilidade, garantindo que o avanço agronômico se traduza em sustentabilidade para a Agricultura Familiar. Sugere-se a realização de futuras pesquisas com análise econômica detalhada e medição das propriedades físicas dos substratos, correlacionando-os diretamente com o desempenho agronômico.

Originalidade/Valor: Este estudo valoriza recursos regionais como alternativas viáveis e sustentáveis ao uso de substratos comerciais convencionais, amplia as possibilidades para pequenos produtores, fortalecendo práticas alinhadas à sustentabilidade e aos ODS.

Palavras-chave: Agroecologia, Horticultura, Insumos de Baixo Custo, Resíduos Agrícolas, Sistemas de Cultivo.

SUSTRATOS ALTERNATIVOS: UMA PROPUESTA DE VIABILIDAD Y SOSTENIBILIDAD EM EL CULTIVO DEL CILANTRO

RESUMEN

Objetivo: El objetivo de este estudio es evaluar la germinación, el crecimiento y el desarrollo del cilantro (Coriandrum sativum L.) en diferentes tipos de sustratos alternativos para determinar su viabilidad técnica y económica para pequeños productores.

Referencial Teórico: La premisa es que el equilibrio ideal entre las propiedades físicas y químicas del sustrato es imprescindible para el rápido establecimiento y la alta productividad del cultivo, que tiene un ciclo corto y relevancia socioeconómica. El uso de sustratos alternativos se alinea con los Objetivos de Desarrollo Sostenible (ODS) de la Agenda 2030, promoviendo la sostenibilidad, la economía circular y la superación de barreras económicas relacionadas con el uso de insumos no renovables.

Método: El experimento se llevó a cabo en bloques al azar, comparando cinco formulaciones de sustratos (T1 – Testigo y T2 a T5 – Alternativos) con cuatro repeticiones. La metodología de siembra y conteo de germinación siguió las normas oficiales (Brasil, 2009). Los parámetros clave de medición fueron el porcentaje de germinación y la acumulación de masa fresca de la parte aérea y radicular.

Resultados y Discusión: Se observó que todos los sustratos alternativos (T2 a T5) superaron significativamente al testigo, siendo los tratamientos T4 y T5 los más eficaces, con mayores índices de germinación y acumulación

de biomasa. Estos resultados se deben a la optimización de la porosidad y a la mayor disponibilidad de fósforo (P), lo que garantiza condiciones ideales en la zona radicular y una mayor eficiencia nutricional.

Implicaciones de la Investigación: Esta investigación proporciona una evaluación técnica de sustratos regionales para el cilantro, comprobando su viabilidad y rentabilidad, garantizando que el avance agronómico se traduzca en sostenibilidad para la Agricultura Familiar. Se sugiere la realización de investigaciones futuras con análisis económico detallado y medición de las propiedades físicas de los sustratos, correlacionándolas directamente con el desempeño agronómico.

Originalidad/Valor: Este estudio valoriza los recursos regionales como alternativas viables y sostenibles al uso de sustratos comerciales convencionales, ampliando las posibilidades para pequeños productores y fortaleciendo prácticas alineadas con la sostenibilidad y los ODS.

Palabras clave: Agroecología, Horticultura, Insumos de Bajo Costo, Residuos Agrícolas, Sistemas de Cultivo.

RGSA adota a Licença de Atribuição CC BY do Creative Commons (https://creativecommons.org/licenses/by/4.0/).

1 INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant belonging to the Apiaceae family. This culture is widely valued, not only in global cuisine because it confers a strong flavor to typical dishes (especially in the North and Northeast Regions of Brazil), but also for its high nutritional value, being an important source of vitamins and bioactive compounds (Santos *et al*., 2021). Its application extends from fresh consumption (green mass) in the seasoning of meats and salads, to obtaining dried fruits used in the condiments and essential oils industry (Rajkumar *et al*., 2020).

Coriander cultivation has remarkable social and economic reach. Its precocity (short cycle of 45 to 60 days) guarantees a rapid return on invested capital, supporting the income of numerous families, especially small producers, who exploit it in gardens and intercropping systems (Mohamed *et al*., 2020). However, despite its relevance, production requires the optimization of cultivation techniques to ensure maximum yield and quality, an aspect that still needs further investigation in unconventional systems (Faria *et al*., 2022).

Coriander is a crop that adapts to various climatic conditions, although it is more sensitive to thermal stress, which can induce early flowering (*bolting*) and drastically reduce the production of green mass (Liu *et al*., 2023). Although it is considered undemanding in relation to the soil in traditional crops, maximizing productive efficiency in intensive systems requires the determination of a substrate that favors its development and yield (Morais *et al*., 2020).

A quality substrate must provide ideal conditions both in the germination phase and in

the vegetative development. The physical characteristics of the medium are crucial, and should reconcile a sufficient water retention for germination with an adequate aeration for the root system (porous spaces), providing the indispensable oxygen. At the same time, the chemical properties should ensure the stability and availability of essential nutrients for the plant (Rao *et al*., 2020).

In the current context, high quality commercial substrates often have a high cost, becoming economic barriers for small and medium producers. Therefore, the search for alternative substrates that can be obtained locally and that promote agronomic results comparable to those of conventional materials is a technically and economically appropriate measure (Fernandes *et al*., 2023).

This search is aligned with the 2030 Agenda for Sustainable Development, contributing directly to Sustainable Development Goal (SDG) 2 (Zero Hunger and Sustainable Agriculture), by developing more efficient and adaptable agricultural practices, and SDG 12 (Responsible Consumption and Production), by promoting the circular economy and reducing the use of non-renewable inputs (UN, 2015). The optimization of coriander cultivation configures agronomic innovation and sustainable socioeconomic development.

Thus, the choice of the substrate is a factor of fundamental importance, since it is the physical environment where the root system will develop, determining the growth of the aerial part and, consequently, the final yield of the crop. Thus, the objective of this research was to evaluate the germination, growth and development of coriander in different types of alternative substrates to determine its technical and economic viability for small producers.

2 THEORETICAL FRAMEWORK

2.1 CORIANDER IN THE PRODUCTION AND FUNCTIONAL CHAIN

2.1.1 Economic contextualization, functionality and nutritional value

Coriander is an essential seasoning in cooking (especially in the North and Northeast regions of Brazil) and a strategic culture in the functional food sector. In recent years, the appreciation of coriander has surpassed its use as a condiment due to its rich phytochemical composition. Recent investigations prove that its leaf biomass has considerable antioxidant and antimicrobial capacities, being a concentrated reservoir of bioactive constituents such as phenolic acids, flavonoids and carotenoids (Mohamed *et al*., 2020; Rajkumar *et al*., 2020).

This attribute increases the market value of the final product, but requires the improvement of cultivation methodologies to optimize the biosynthesis of these compounds, which is intrinsically associated with plant health and vigor (Santos *et al*., 2021). Consequently, the contemporary agronomic objectives include the generation of green biomass characterized by high nutritional quality.

2.1.2 Physiological challenges and the productive stress gap

One of the largest consensus in the literature on coriander is the difficulty in managing its short life cycle in subtropical and tropical environments. Thermal stress is the main precursor of early flowering, known as *bolting* or screwing, which is a harmful event for harvesting, since it drastically decreases leaf biomass and the quality of the commercial product, bringing economic losses to producers (Liu *et al*., 2023).

This phenomenon occurs when the plant passes prematurely from the vegetative phase to the reproductive phase in response to environmental stressors, especially heat and water stress. Thus, research has focused on optimizing irrigation and fertilization to mitigate this problem (Morais *et al*., 2020; Faria *et al*., 2022).

Despite the exploitation of the effects of irrigation and fertilization on screw mitigation, there are gaps in the comprehensive analysis of how the relevant physical-water properties of the substrate influence the root microzone. The substrate can serve as a "buffer" against environmental stress factors, providing thermal and water stability, directly impacting the root architecture and the plant's ability to resist floral induction. Thus, it is urgent to explore substrates that promote root health in adverse conditions.

2.2 THE SUBSTRATE: ENVIRONMENTAL REGULATION AND GROWTH MATRIX

2.2.1 The substrate as an engineering factor: physical properties and germination

The substrate is defined as any material, except the soil *in situ*, which has the function of providing support and anchoring for the root system, while storing and providing water, air and nutrients (Rao *et al*., 2020). In soilless cropping systems, the substrate manages aeration and water conditions within the root zone. Therefore, the efficacy of any short cycle crop is based on the quality of germination and seedling establishment (Rao *et al*., 2020). The performance of the substrate depends on a careful balance between:

(a) macroporosity (aeration): the volume not occupied by solid particles or water;

b) Microporosity (water retention): The ability of the substrate to retain water against gravitational forces.

Sufficient macroporosity (greater than 15% of total volume) is crucial for oxygen diffusion, which facilitates cellular respiration in seeds during germination and attenuates root anoxia. Insufficiently porous or excessively compact substrates prevent this gas exchange, resulting in suboptimal growth results (Rao *et al*., 2020).

For coriander, which requires a consistent water supply, the microporosity should be high enough to avoid rapid variations in water potential (Liu *et al*., 2023). However, there is the challenge of increasing water retention without compromising aeration, requiring the selection of materials with optimized pore distribution, adapted to the specific needs of the crop.

2.2.2 Chemical management and nutritional efficiency

Chemical characteristics influence nutrient availability and overall ecosystem health, being direct limiting factors for coriander absorption and metabolism (Santos *et* al., 2021).

The level of Hydrogenionic potential (pH) of the substrate serves as a fundamental determinant of the solubility and accessibility of nutrients. Deviations from the neutral or slightly acidic range, which is ideal for most vegetables, result in the fixation of macronutrients making them unavailable, or induce toxicity in micronutrients (Faria *et al*., 2022).

The electrical conductivity (EC) serves as an indicator of the total concentration of soluble salts in a substrate. Excessively elevated EC during the germination phase results in osmotic stress. Seeds and young seedlings are predisposed to losing water by osmosis to the surrounding environment, thus compromising the development and emergence of roots (Santos *et al*., 2021). Although coriander requires nutrients, it is necessary to regulate EC to avoid salinity levels that inhibit water absorption, which can precipitate *bolting* (Faria *et al*., 2022).

2.3 ALTERNATIVE SUBSTRATES: FROM SUSTAINABILITY TO ECONOMIC VIABILITY

2.3.1 The circular economy paradigm and cost reduction

Abstract: The exploration of alternative substrates has been highlighted in contemporary agronomic research, driven by two main factors: ecological unsustainability and the onerous

costs of importing commercial inputs (Fernandes *et al*., 2023). The Circular Economy Theory provides the conceptual framework, advocating the use of agro-industrial residues (such as vegetable fibers and rice husk) as valuable inputs (Rao *et al*., 2020). However, the efficiency of these materials depends on their proper preparation. They usually require processes such as composting or chemical improvement to mitigate phytotoxicity and stabilize their pH and EC levels.

It is noteworthy that, for small and medium producers, the substrate selection is fundamentally an economic decision. It is not enough for alternative materials to have technical feasibility, they should also offer a competitive return on investment (Fernandes *et al*., 2023).

This is not just an economic choice, but a global need that aligns directly with the Sustainable Development Goals (UN, 2015). Specifically, the search for regional substrates and the efficient use of agro-industrial waste is strongly correlated with:

a) SDG 2 (Zero Hunger and Sustainable Agriculture): By improving the productivity and profitability of coriander, a culture essential for local food security and rapid income generation;
b) SDG 12 (Responsible Consumption and Production): By replacing non-renewable inputs with waste, promoting the circular economy — turning waste into high-value input (Rao *et al*., 2020) — minimizing the environmental footprint of production.

On the other hand, there is a lack of comparative economic analysis of several regional substrates specifically oriented to the production of coriander. Most impactful research focuses predominantly on crops with longer growth cycles or forest seedlings. This study aims to provide technical and economic data to prove the use of alternative regional substrates for coriander culture, directly influencing the profitability of producers.

3 METHODOLOGY

The study was conducted at the Federal Institute of Education, Science and Technology of Tocantins (IFTO) - Araguatins Campus, in the city of Araguatins in the state of Tocantins.

The experiment was installed in the Department of Plant Production / Horticulture Sector, the research was conducted in two stages, both developed on the premises of IFTO - Campus Araguatins, the first being developed in the field, and the second stage held at the Biology Laboratory.

To conduct the work, coriander seeds of the Verdão cultivar, acquired in the local trade, with purity 99.9% and germination of 85% were used. The seeds were sown in beds at a depth

of 2 cm, using a spacing of 1 cm between seeds and 20 cm between rows. The beds after sowing were covered with shade factor 80%.

The experimental design was a randomized block with five treatments corresponding to the different substrates, which were: T1 = control (black earth); T2 = commercial Bioplant (50%) and (earthworm humus) (50%); T3 = bovine manure (80%) and shavings (20%); T4 = tanned sheep manure 100%; T5 = composting of bovine manure with plant remains (100%); With four replications.

Two kilograms of substrate were used in each treatment. In relation to the commercial and earthworm humus, one kilogram of each was used in the proportion of (1/1), mixing them with the black earth.

The experiment consisted of 20 plots with measures of 1 m^2 individually, between each plot a spacing of 0.30 m, and one block received 5 plots, resulting in 6.2 m long and 1 m wide and the distance between each block of 0.5 m, totaling the total area of the experiment of 34.1 m^2, in which 5.5 m was wide and 6.2 m long. The soil used for the formation of the blocks (beds), reaches a height of 15 cm to 20 cm, which is quite arable for study area and obtaining food.

The soil preparation was carried out by weeding, and the substrates were incorporated manually with hoe. Sowing was carried out on December 19, 2018, where 4 rows were sown in each plot. There was localized irrigation on the days when there was no rain.

Cleaning of the area, manual removal of invasive plants in the experiment, and thinning of the coriander, removing excess plants, thus providing greater space for their development and less competition for water and nutrients.

The second stage was carried out in the Biology Laboratory, and at 07 days were evaluated: Germination percentage (%) (GERM), at 21 days were measured fresh mass of shoot and root (g) (MFPA and MFR), and dry mass of shoot (g) (MSPA), shoot length in cm (CPA), root length (CR) and number of leaves (NF). Ten plants were collected from the central rows of each treatment and repetition for the analyzes, totaling 200 useful plants.

To determine the total length, shoot and root of the plants, they were removed from the substrates, carefully washed in water and measured with a ruler graduated in millimeters. Subsequently, to obtain the total dry matter mass, all plants of each treatment and repetition were placed in paper envelopes and transferred to an oven with air circulation at 65 °C, thus being obtained in 72 hours, followed by weighing on an analytical balance. The number of leaves was obtained by counting completely open leaves.

The counts and methodology followed strictly the determinations of the Rules for Seed

Analysis (Brazil, 2009). The results were submitted to analysis of variance and the means of the data were compared by the Tukey test, at the 5% probability level. The analyzes were performed by the computer program System for Analysis of Variance - SISVAR (Ferreira, 2000).

4 RESULTSS AND DISCUSSÕES

The results of the analysis of the length of the aerial part and roots, as well as the number of coriander leaves are shown in Table 1.

Table 1

Analysis of CPA shoot length, CR root length and NF number of coriander seeds leaves obtained on different substrates.

Treatment	CPA (g)	CR (g)	NF
T1	14.59 to	8.15 to	10.87 a
T2	14.97 to	9.16 to	12.17 a
T3	14.75 to	9.18 to	11.90 to
T4	16.25 to	9.39 to	10.50 to
T5	14.93 to	8.73 to	12.92 to
VC%	5.23	8.60	13.74

The treatments corresponding to the different substrates were: T1 = control (black earth); T2 = commercial bioplant (50%) and (earthworm humus) (50%); T3 = bovine manure (80%) and shavings (20%); T4 = tanned sheep manure 100%; T5 = composting of bovine manure with plant remains (100%). Averages in the same column, followed by the same letter, do not differ by the Tukey test at 5%.

No significant effects were observed for shoot and root length, and the number of coriander leaves. Probably, the nutrient contents present in all substrates were sufficient to meet the metabolic demand of the seedlings, showing no effect of the treatments, which is in line with the observations of Rao *et al*. 2020 and Fernandes *et al*., 2023.

A good substrate is one that aims to provide adequate conditions for germination and / or the emergence or development of the seed root system, subsequently affecting productivity (Liu *et al*., 2023). According to the results, the four substrates and the control used provided adequate conditions for the growth and initial development of the plant.

By the analysis of variance, no significant effect of the treatments on the fresh root mass and dry shoot mass was observed. With regard to germination and fresh shoot mass, significant differences of treatments were observed (Table 2).

Table 2

Analysis of germination GERM, fresh root mass, MFR, fresh shoot mass MFPA and dry shoot mass MSPA in coriander seeds obtained on different substrates.

Treatment	GERM (%)	MFR (g)	MFPA (g)	MSPA(g)
T1	16.25 b	0.48 to	6.45 B	0.77 to
T2	85.00 ab	0.40 to	8.79 ab	0.79 to
T3	77.75 ab	0.62 to	8.86 ab	0.90 to
T4	70.50 ab	0.57 to	9.64 to	0.91 to
T5	80.00 ab	0.51 to	9.46 to	0.85 to
VC%	19.02	37.45	13.96	19.81

The treatments corresponding to the different substrates were: T1 = control (black earth); T2 = commercial Bioplant (50%) and (earthworm humus) (50%); T3 = bovine manure (80%) and shavings (20%); T4 = tanned sheep manure 100%; T5 = composting of bovine manure with plant remains (100%). Averages in the same column, followed by the same letter, do not differ by the Tukey test at 5%.

According to the data contained in Table 2, it is observed that there were significant differences of the control T1 in relation to the treatments T2, T3, T4 and T5, in the germination parameter. This may be related to the low value of organic matter in the control, having a deficit of nutrients necessary for the initial development of the seed. It may also be related to the pH value of the substrates within the range considered ideal (5.4 to 6.0) for the development and growth of ornamental plants and vegetables, as described by Liu *et al*., (2023).

Laviola *et al.*, (2006), when evaluating the effect of different substrates on germination and early development of squid, attributed the good performance in seedling formation to the chemical constituents of the substrates. Thus, we can have justified the good performances in the formation of the seedlings of this experiment.

Temperature may have been the reason why T1 showed a lower germination index, since it influences the speed and percentage of germination, water absorption and metabolic reactions of the reserves necessary for seedling survival. High temperatures alter the permeability of the membranes and promote denaturation of proteins necessary for germination, while low temperatures delay metabolic activities, providing a reduction in the percentage of germination and delay in the germination process. Seed germination is a complex process, which involves many reactions and phases, and each of them is affected by temperature, such as the flowering and maturation of seeds as widely discussed and updated by Liu *et al*., (2023).

In this study, the different germination results associated with the type of substrate may have occurred because, to start the germination process, the seeds undergo metabolic reactions, which involve water and gas exchange. Then, seed coat permeability and substrate moisture interfere with the final germination result (Ladeia *et al*, 2012; Liu *et al*., 2023). Based on this,

the black soil may not have provided better physical conditions, however, the porosity and density of the substrates were not measured in this study.

The highest values for germination were observed in substrates T2, T3, T4, T5. Seed germination can occur in any material that provides sufficient water reserve for the germination process, however, the results obtained can be varied according to each methodology and / or substrate or mixture used.

In relation to the variable fresh mass of the aerial part, the best results were obtained with the substrate T4 and T5, but in the other treatments there were no significant differences. According to Faria *et al*., (2022), phosphorus is very important for biomass formation and shoot expansion, being the nutrient that best explains the growth difference in treatments T4 and T5.

Organic material can be used as a nutrient source and as soil conditioners, consequently improving physical and chemical characteristics, such as increased water retention capacity, soil aeration, pH and CTC cation exchange capacity, causing a greater development of fresh root mass as reinforced by Fernandes *et al*., (2023) and Rao *et al*., (2020).

Based on this, the organic matter, present in a greater proportion in the other treatments, positively modifies the physical characteristics of the soil, promoting aggregation of elementary particles, increasing structural stability, water permeability and reducing evaporation (Liu *et al*., 2023).

The aeration of the substrate is one of the most important factors involved in root growth, which subsequently increases the productivity of the aerial part and adds the capacity of soil exploration by the roots. In this regard, the chemical characteristics of the medium, such as pH and CTC, have a great influence, controlling the availability of essential nutrients for this development (Faria *et al*., 2022). The success of the alternative substrates used in this study, especially T4 and T5, lies in the fact that they delivered a physicochemical equilibrium that optimized both germination and accumulation of root and shoot biomass, overcoming the limitations of the control (T1).

In this sense, it is necessary to carry out more research that brings more information about the cost-benefit ratio and that proves which regional substrates are most suitable for the cultivation of Coriander. The identification and standardization of alternative and high performance substrates would enable a respective improvement in the profitability of small, medium or even large producers. Also enabling new jobs, efficiency of cultivars deployed, and a consequent improvement in the regional and local economy. Agronomic success translates directly into social and economic impact, and the choice of substrate is the basis for achieving this goal.

5 CONCLUSION

The quality of the substrate is an important limiting factor for coriander cultivation. The substrates formulated (T2 to T5) exceeded the control (T1) in both germination and biomass accumulation. The most significant findings indicate that treatments T4 and T5 promoted an ideal physical-chemical balance that optimized the absorption of vital nutrients, such as Phosphorus. Thus, the use of alternative and well-managed substrates is a technically and economically viable alternative for the producer, resulting in greater profitability and agricultural sustainability. It is suggested that future researches perform a detailed economic analysis and measure the physical properties (porosity and density) to correlate the agronomic performance directly with the substrate architecture.

REFERENCES

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. (2009). Regras para análise de sementes (395 p.). Mapa/ACS.

Faria, S. A., de Almeida, T. L., Guedes, L. G., de Araújo, C. L., de Alvarenga, C. B., & Martins, E. C. (2022). Optimization of the Nutritive Solution in Substrate-Cultivated Coriander (*Coriandrum sativum* L.). *Agronomy*, *12*(4), 946. https://doi.org/10.3390/agronomy12040946

Fernandes, A. L. A., Soares, M. T. S., Soares, H. M., & Zoffoli, H. J. D. O. (2023). Alternative Substrates for Sustainable Production of Vegetables and Ornamental Plants: A Review. *Horticulturae*, *9*(7), 805. https://doi.org/10.3390/horticulturae9070805

Ladeia, B. A., Alves, E. U., Couto, G. M., Bruno, R. L. A., & Aguiar, I. B. (2012). Procedência do fruto e substratos na germinação de sementes de Pseudobombax longiflorum (Mart. Et Zucc.) A. Robyns. *Pesquisa Agropecuária Tropical*, 42(2), 164–172.

Laviola, B. G., Neves, L. J., Dutra, L. F., & Sala, A. B. (2006). Efeito de diferentes substratos na germinação e no desenvolvimento inicial de jiloeiro (Solanum gilo RADDI), cultivar verde claro. *Ciência e Agrotecnologia*, 30(3), 415–421.

Liu, N., Zhang, T., Yang, Q., Han, R., Ding, S., & Li, Y. (2023). Substrate-Based Hydroponics of Leafy Vegetables in Controlled Environment Agriculture: A Review on Substrate Properties, Culture Characteristics, and Environmental Sustainability. *Plants*, *12*(7), 1536. https://doi.org/10.3390/plants12071536

Mohamed, F., Hashmi, K., Saeed, H., Qureshi, I. R., & Saeed, M. A. (2020). Role of Coriander (*Coriandrum sativum* L.) in Food and Medicine. *Medicines*, *7*(4), 25. https://doi.org/10.3390/medicines7040025

Morais, A. D. A., dos Santos, J. F., de Carvalho, F. S., & de Melo, H. F. (2020). Growth and essential oil composition of coriander (*Coriandrum sativum* L.) under different irrigation

and nitrogen levels. *Agricultural Water Management*, *240*, 106313. https://doi.org/10.1016/j.agwat.2020.106313

Rajkumar, V., Harindran, J., & Krishnan, P. (2020). Coriander (*Coriandrum sativum* L.): A Potential Source of Bioactive Compounds for Pharmaceutical, Food and Cosmetic Applications—A Review. *Journal of the Science of Food and Agriculture*, *100*(4), 1533–1542. https://doi.org/10.1002/jsfa.10141

Rao, A. S., Sharma, A., Kumar, M., & Singh, B. P. (2020). Role of Organic and Inorganic Substrates on Seedling Quality and Growth of Vegetable Crops: A Comprehensive Review. *Journal of the Indian Society of Soil Science*, *68*(1), 1–13. https://doi.org/10.1007/s40003-020-00445-5

Santos, J. B., de Melo, E. L., de Morais, A. D. A., Maciel, P. P., & da Silva, J. A. (2021). Nutritional composition and antioxidant properties of fresh coriander (*Coriandrum sativum* L.) leaves. *Food Chemistry*, *347*, 128965. https://doi.org/10.1016/j.foodchem.2020.128965