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EXPERIMENTATION IN BIOLOGY AS AN INSTRUMENT FOR THE UNDERSTANDING AND CONSTRUCTION OF SCIENTIFIC KNOWLEDGE IN TEACHER TRAINING

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ABSTRACT
The study analyzed the importance of experimental practices in the teaching of biology to help students understand biological processes, using papaya, beet and pepper seeds in different types of substrates that were the following: coarse sand, leaf litter and commercial substrate, in this way, the research sought to evaluate the germination index of the seeds of these vegetables, in which it was observed in which substrates the vegetable seeds had a higher germination. The methodology included theoretical classes in the disciplines of physiology and plant ecology, in addition, combining it with the practices that included the preparation of sowing and observation of germination, thus bringing practical classes as complements to theoretical classes, thus promoting skills such as hypothesis creation and data analysis, in addition to developing teamwork and problem-solving skills. Therefore, the work is divided into five sections (introduction, literature review, methodology, results and discussion, final considerations), in this way, the study highlights the relevance of experimentation in science education, evidencing its positive impact on teacher training and biology teaching.

Keywords: Plant Physiology, Biology Teaching, Vegetable Crops, Seed Germination.

INTRODUCTION

Teaching should be a process of collective construction of knowledge, in which educator and student recognize themselves as subjects of the educational process Libâneo (2017), in this way, the diversity of teaching methods, such as experimentation and experimental practices in general, reflects different conceptions about how students learn, develop and progress their assimilation.

In this context, teaching science and biology through experimentation is indispensable for the understanding and construction of scientific knowledge. The importance of practical activity is unquestionable in teaching and should have a central place in education (MELLO, 2010). In this way, experimentation comes as a watershed, thus becoming a facilitator for understanding in the teaching of biology.

According to Santos (2005), teaching through experimentation is almost a necessity in the scope of the natural sciences. According to (SILVA *et al*., 2024), theory, when reconciled with experimental practice, provides better scientific knowledge to the student, even more so when the object of study is present in their daily life, triggering curiosity about the chemical and biological processes present in their surroundings.

In controversy, it is seen that some schools do not have laboratories for experimental classes, so experimental practice in schools that do not have this contribution is difficult. In this way, the teacher is essential to bring practices allied with something experimental, thus providing this perspective to students.

According to Silva et al. (2009), when experimentation is developed together with contextualization, that is, taking into account socio-cultural and economic aspects of the student's life, the learning results can be more effective. In this way, theoretical classes, together with practical ones, help students in the teaching-learning process, acting as a facilitator for the understanding of the contents in the teaching of biology.

In addition, in the context of the chemical and physiological processes of plants, the use of vegetable varieties in classroom experimentation can enrich students' learning about biodiversity and sustainable agricultural practices. Thus, Silva et al. (2015) emphasize that genetic diversity in crops allows for a broader understanding of adaptation and resistance to adverse conditions. In this sense, conducting experiments with different substrates provides valuable practical experience for students.

Faced with such a scenario, Santana and Almeida (2017) state that experimental activities facilitate the connection between theory and practice, promoting significant learning about biological processes. In addition, experimental practice not only increases knowledge about biology but also develops essential scientific competencies. Gil-Pérez et al. (2009) highlight that practical experiences in science help students develop critical skills, such as systematic observation and data analysis.

Experimental activities are fundamental in the contextualized approach to Biology contents, as they also allow students to relate scientific theories to the reality of their daily lives. By conducting experiments on seed germination in different substrates, for example, students not only observe biological phenomena in action, but also understand the importance of substrate choice for growing vegetable crops in their communities. About this we can state that:

> The experimental activities allow students to establish a relationship between the theory developed in the classroom with their daily lives and the realities of the social transformations that take place in their surroundings. Thus, experimental practice is a pedagogical modality of vital importance, where the student puts into practice hypotheses and ideas learned in the classroom about natural or technological phenomena and that are present in their daily lives (PEREIRA et al., 2024, p. 2).

In addition, experimentation also facilitates the understanding of complex concepts, such as the processes of photosynthesis and cellular respiration, by allowing students to carry out direct measurements and observations. Thus, by integrating experimentation into the Biology curriculum, educators not only enrich learning but also prepare students for a deeper understanding of biological phenomena and their real-world application. Thus, according to Pereira et al. (2013, p.3) highlight:

> From this point of view, experimental classes constitute a didactic strategy that fosters the development of these skills. In them, the student is instigated to think and confront theoretical knowledge articulated with experimental practice and, thus, according to their needs to apply it in their daily lives, in this sense, it is important that the teacher has a reflective posture towards their professional practice, and thus contribute to improvements in the quality of science teaching (PEREIRA, et.al, 2013, p.3).

Within this context, activities both in the laboratory and in places conducive to this can function as a counterpoint to theoretical classes, as a powerful catalyst in the process of acquiring new knowledge, as the experience of a certain experience facilitates learning (POSSOBOM et al., 2003). In view of this, it is of paramount importance that the teacher provides situations that enable the development of metacognitive skills, here understood as the ability to understand, discuss and evaluate the knowledge acquired, being a brilliant stimulator of teaching-learning.

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Therefore, it is worth noting that experimentation in practical classes is fundamental for teacher training in Biology, as it provides future educators with a deep understanding of the contents and teaching methodologies. By conducting experiments, trainee teachers not only assimilate theoretical knowledge, but also develop essential practical skills, such as lesson planning, conducting experiments, and critically analyzing the results.

Also, these practical experiences allow teachers to better understand the difficulties faced by students and the strategies necessary to overcome them. Since the experience in laboratories and experimental activities stimulates reflection on pedagogical practice and promotes a more contextualized approach to teaching by integrating experimentation into teacher training, it is possible to train professionals who are more prepared to teach Biology in a dynamic and effective way. This practical experience is essential for teachers to feel confident when conducting similar activities with their students.

Practical classes expose future educators to the diversity of students and learning styles. They learn to adapt their approaches to meet different needs, fostering an inclusive and collaborative environment in the teaching of Biology. These aspects show how experimentation in practical classes is a powerful tool in teacher training in Biology licentiate, preparing future educators for real challenges in the classroom.

Therefore, experimentation helps connect theoretical concepts to reality, making learning more meaningful. Teachers in training learn the importance of applying theory in practical situations, which facilitates students' understanding when these concepts are later presented in the classroom. Teachers who experience experimentation are more likely to incorporate hands-on activities into their future lessons, which can increase student motivation and engagement. In this way, practical experiences often arouse students' interest in Biology, making learning more attractive.

MATERIALS AND METHODS

LOCATION OF THE RESEARCH

This is an experimental research carried out in a greenhouse, belonging to the State University of Alagoas, Campus I, located in the municipality of Arapiraca, Alagoas, at the following coordinates 9°44'54"S 36°39'14"W 2 905 m between the months of March and November 2024, a period that is characterized by the presence of rainfall with milder temperatures around 250 C. For the application of pedagogical practice and teaching in science and biology.

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The use of experimental or investigative projects gives students the opportunity to solve problems, research, experiment, thus having the possibility to discuss, study to define possible solutions. These activities with open and discursive purposes can be carried out by students both individually and in groups with guidance, linked to the contents that are studied in the classroom in the teaching of biology.

METHODOLOGICAL PROCEDURES

The research was conducted in a university greenhouse that has a chapel shape, covered by shading screen specially designed for agricultural greenhouses; having a shade with 50% coverage. What's more, the greenhouse structure has the brand of hydrogood®. Seeds of three vegetables were used: beets (katrina), peppers (giant ruby), papaya (formosa).

For the consolidation of the data, the methodological triangulation method was used, which involves an approach that uses several research methods, thus collecting and consequently analyzing the data that were obtained through the study in question. According to Stake (1995), triangulation is a strategy that increases the accuracy of case study and research protocols, thus allowing the investigation of specific causes or events in the theme addressed.

The study arose during the disciplines of plant physiology and plant ecology, which were taught during the period of one academic semester of the biological sciences course, in which the participation of students was focused on theories and practices, where the germination index of vegetable seeds was monitored.

For the production of the work, the seeds were placed in trays with 200 cells each. In each tray, three types of substrates were distributed equally: coarse sand, vegetable soil for vegetables and leaf litter.

To prepare the substrates to be placed in the seedbeds, the following was done: in the case of coarse sand, only coarse sand was collected at its maximum capacity for standardization; in the litter, the sieving took place to make it well permeable; In the commercial substrate, as it is already ready, we only put it in the cells. As soon as the substrate was deposited in the tray, it was watered before we placed the seeds, in each cell of the seedbed 2 seeds were placed to observe the germination, after that, we water every day very carefully so that it does not exceed the amount of daily water and that the jet does not take the substrate from the cells.

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DATA ANALYSIS

The data were analyzed by the monitoring record every day from germination in an Excel spreadsheet. The germination speed index (IVG) was calculated by the sum of the number of seeds germinated each day, divided by the number of days elapsed between sowing and germination, according to Maguire's formula (1962). The germination index (GI) was also applied, and for the calculation of the germination percentage, the formula GI = (N/A) · 100 was used, according to Brasil (1992). The average germination time (MGR) refers to the sum of the number of germinated seeds multiplied by the incubation time in days, divided by the sum of germinated seeds per day (LABOURIAU, 1983).

$$IVG = (G1/N1) + (G2/N2) + (G3/N3) + ... + (1)$$

(Gn/Nn), where:

IVG = germination speed index,

G1, G2, G3, ..., Gn = number of sampling units (seedlings) computed in the first, second, third and last count;

N1, N2, N3, ..., Nn = number of days from sowing to the first, second, third and last.

IG = (N/A) · 100

G: is the germination percentage

N: is the number of germinated seeds

A: is the total number of seeds placed to germinate

TMG=(∑in)/∑in, no qual:

Ni: is the number of seeds germinated per day

IT: It's the incubation time

Units: days

The data were tabulated in Excel and then submitted to analysis of variance and Tukey's test at the level of 5% to compare the means, using the statistical software SISVAR 5.6 (FERREIRA, 2011).

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RESULT AND DISCUSSION

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 (LAVIOLA et al. 2006).

There was a significant difference between the different treatments for the variable germination speed index in the three species studied. Papaya seeds showed the highest IVG in the treatment containing litter with an average of 3.78, followed by the treatment with commercial substrate (1.91) and coarse sand (1.57). It is observed that these results are similar to the germination speed index of pepper seeds, which in turn presented indices of 3.78 for litter treatment, 1.56 for coarse sand and 1.09 for commercial substrate. For the beet crop, the commercial substrate promoted a higher germination speed index (9.06), followed by the treatment containing litter (4.56) and coarse sand (1.09) (Figure 1).

In general, it is observed that the treatment containing litter is a promising source of organic matter for the composition of substrate used in the germination and production of vegetable and fruit seedlings. In the present study, litter stood out for promoting the acceleration of the germination process of papaya and pepper seeds in relation to the commercial substrate.

Silva et al. (2011), observed that papaya can be less demanding in terms of the type of substrate, adapting well to different conditions. In addition, Holanda et al (2015) highlight that the organic matter present in litter can provide essential nutrients and promote a favorable environment for germination. In turn, Costa et al. (2011), commercial substrates often provide an ideal environment for germination due to their balanced nutrient composition.

Regarding experimentation involving germination processes, Leite (2017) addresses that the teaching of biology in practice is of paramount importance for the understanding of life and natural processes. Thus, it requires students to have scientific/practical knowledge, in addition to theoretical classes, so that they can understand in a clearer way the chemical and physiological processes of plants in the germination of their seeds, thus, the study addresses a pedagogical practice from an experimentation using seeds of three types of vegetables and three different types of substrate, in order to evaluate their germination index.

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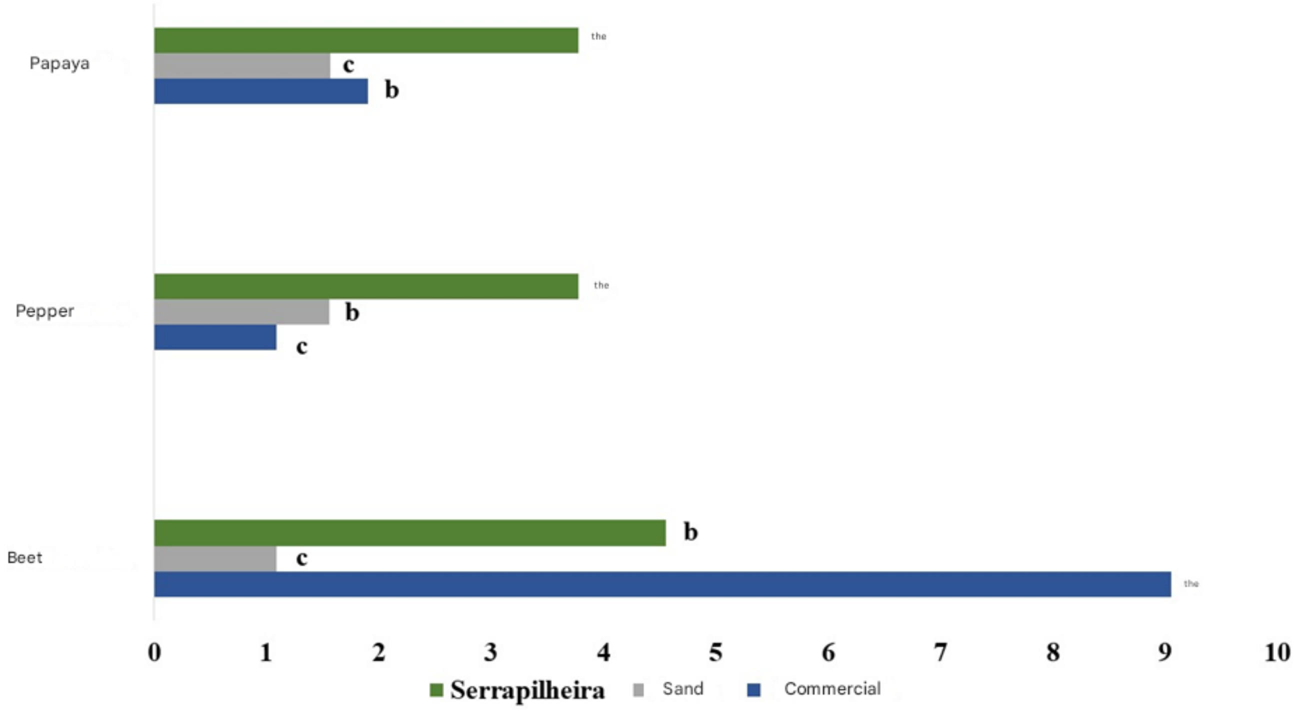
Figure 1. Germination speed index (IVG) in papaya, pepper and beet seeds in different substrates.



Source: Survey data.

Figure 2 shows the results of the Average Germination Time of papaya, pepper and beet seeds. It is observed that there was a statistical difference between the treatments for the germination time of papaya seeds, with emphasis on the treatments containing litter and coarse sand, where they promoted the lowest average germination times with averages of 3.22 and 3.95, respectively. It is noteworthy that the use of the commercial substrate differed from the other treatments, with an average of 6.29, being the treatment with the lowest performance in terms of reducing the germination time of the seeds. In addition, there was no difference at the 5% probability level for the treatments used in the germination of peppers and beets.

In experiments carried out by Diniz; Ataíde (2023) using washed sand, medium vermiculite, coconut fiber and fine vermiculite to estimate the germination performance of pomegranate seeds, it was observed that there was no significant difference for the substrates tested in relation to the percentage of emergence and the average germination time (TMG) of the seeds, however, in the average germination speed (VMG), The best result was found from the use of the thin vermiculite substrate. It is worth mentioning that the granulometry and chemical composition of each substrate are decisive factors, which must be considered for the best germination performance.

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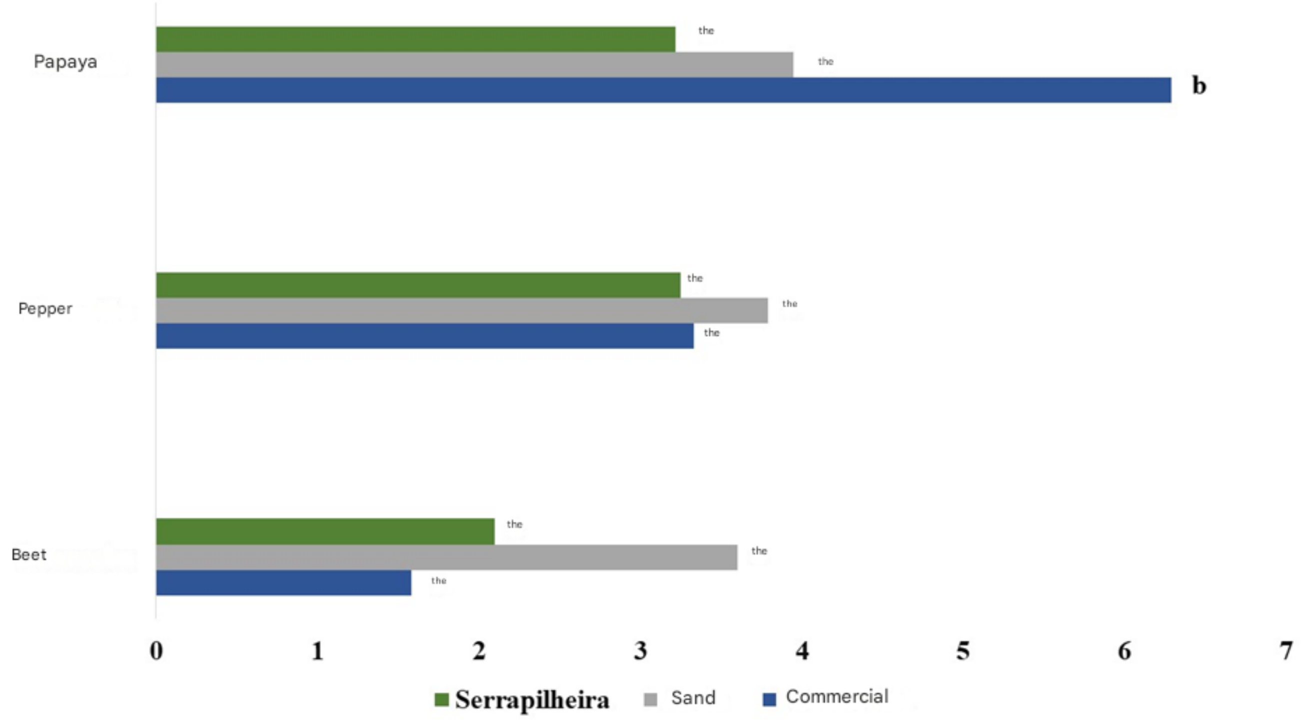
Figure 2. Average germination time (MGR) of papaya, pepper and beet seeds in different substrates.



Source: Survey data.

Figure 3 shows the germination index of the seeds, thus, based on the statistical analysis, it is observed that the equal lowercase letters indicate that there was no significant difference between the treatments for each vegetable seed. Thus, for papaya seeds, the germination percentages were 25% in litter (a), 33.33%, in coarse sand (a) and 33.33% in commercial substrate (a). This suggests that papaya has a greater flexibility in terms of the type of substrate, being able to germinate more efficiently in various conditions. Lima et al. (2018) found that the germination index of Formosa papaya and Hawaiian papaya, using the Bioplant® substrate, obtained the following results: 43.6% for Hawaiian papaya and 41.1% for Formosa papaya in their study.

For the pepper seeds, the germination percentages were 36.66% in the litter (a), 33.33% in the coarse sand (a) and 43.33% in the commercial substrate (a), also showing that they have an adaptation similar to that of papaya, since all the treatments in this result were indicated by the letter "a".

In the case of beets, a significant difference was observed between the substrates, with a germination of 76.66% in litter (a), in coarse sand it showed a germination of 31.66%, indicated by the letter "b" and 96.66% in the commercial substrate (a). This demonstrates that beets are more sensitive to substrate conditions, benefiting more from nutrient-rich and well-structured substrates.

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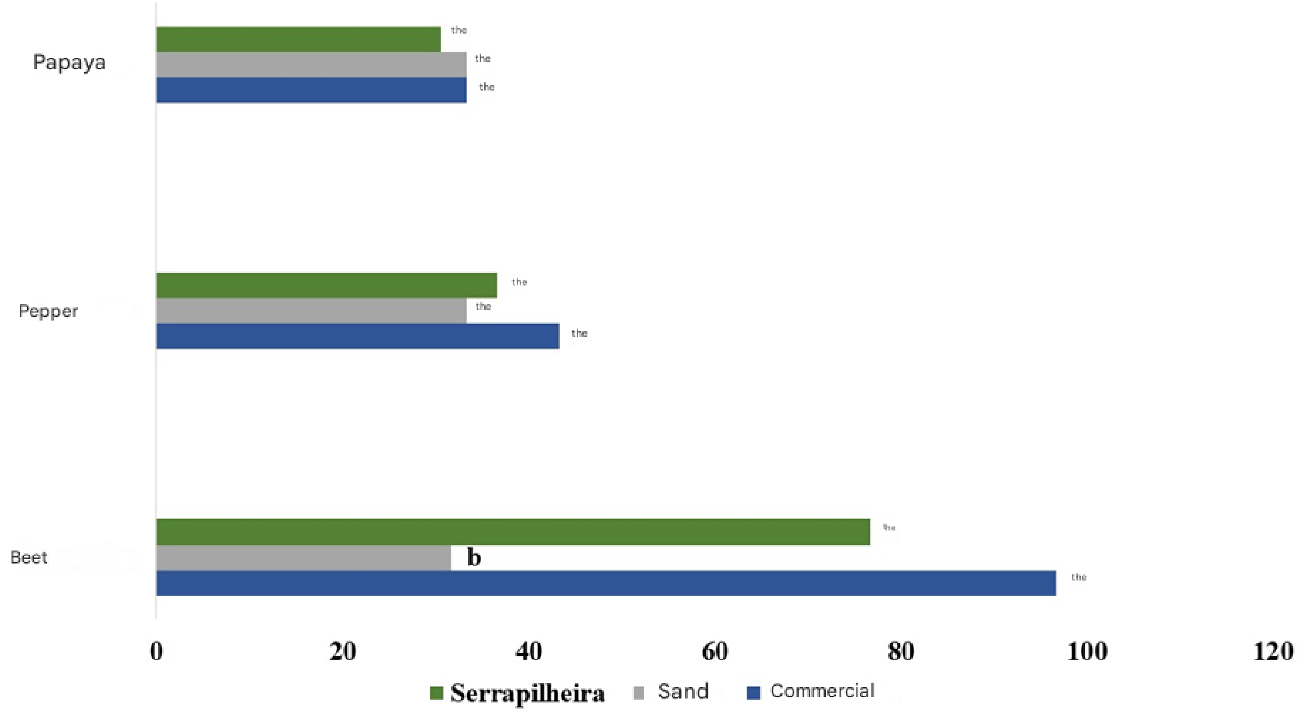
Figure 3. Germination index (GI) in papaya, pepper and beet seeds in different substrates.



Source: Survey data.

These results show the importance of understanding the needs and specificities of seeds, as well as how the different types of substrates influence their germination and the good development of seedlings, with this, this experimentation is a great ally to contribute to the teaching of biology. According to Araújo (2011), experimentation in the teaching of biology arouses a strong interest among students, contributing to a more meaningful learning.

CONCLUSION

The analysis of the data showed that the commercial substrate is the most effective for the germination of beet seeds, while the litter presented better results for the pepper seeds. Papaya seeds showed flexibility regarding the type of substrate, with a slight emphasis on coarse sand. These findings underline the importance of choosing the appropriate substrate for each crop, aiming to optimize germination efficiency and promoting healthy plant growth.

Experimentation in science and biology teaching is essential, as it allows students to actively participate, developing skills such as observation, hypothesis formulation, data collection and analysis, as well as discussing and interpreting results, in addition to promoting teamwork and contributing to problem solving.

Therefore, by integrating the concepts of soil science, plant physiology, and sustainability, teachers can provide critical thinking and interdisciplinary learning, preparing students to face challenges and problems in a well-structured and responsible way. However, the study of the germination rate of vegetable crops not only contributes to the most effective agricultural practices, but also emphasizes the importance of scientific knowledge, making learning more contextualized and with great relevance to the current reality of each student.

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