



Teaching plant physiology: a systematic review during the Covid 2019 pandemic

O ensino de fisiologia vegetal: Uma revisão sistemática durante a pandemia da Covid 2019

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ABSTRACT

The present work seeks to describe and find out which methodologies were most used during emergency remote teaching (ERE) in Brazil that helped in the teaching of plant physiology. To carry out the same, the systematic review method was adopted, where a protocol was built to define the steps that should be followed. A total of 3850 works on the subject were observed, but only 15 were selected to participate in the work. With these articles, it was noticeable that there was a way to give practical classes on plant physiology during the pandemic, with different strategies, teachers managed, despite the difficulties, to find ways to make their students able to understand the various topics on plant physiology.

RESUMO

O presente trabalho, busca descrever e saber quais foram as metodologias mais utilizadas durante o ensino remoto emergencial (ERE) no Brasil que auxiliaram no ensino de fisiologia vegetal. Para a realização da mesma, foi adotado o método de revisão sistemática, onde foi construído um protocolo para definir os passos que deveriam ser seguidos além de definimos a plataforma de busca, foi realizado também um recorte temporal dos anos de 2020-2022. Foi observado ao todo 3850 trabalhos sobre o tema, mas apenas 15 foram selecionados para participar do trabalho. Com esses artigos foi perceptível que teve como se fazer aulas práticas sobre fisiologia vegetal durante a pandemia, com estratégias diversas, os professores conseguiram, apesar das dificuldades, encontrar meios para fazer com que seus alunos conseguissem compreender as diversas temáticas sobre fisiologia vegetal.

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INTRODUCTION

Although plants and their derivatives can be presents in our daily lives and this interaction between them and the human species occurs in different ways, as a nutritional source; in the making of utensils and drugs, composing landscapes in gardens or squares that comprise environments (Arruda 2019, p. 28). The study of the *plantae* kingdom is one of the most outdated areas of biology when we discuss about education. Moul and Silva (2017, p. 265) report that due to the large number of terms specific to the discipline, many students are unable to feel interest in this area. By the way, there is a difficulty in finding support materials that are functional, ways of approaching and also the poor training of teachers. And this shows that, in order to have better results in the other stages of education, it is necessary to reformulate the curriculum for subjects in the botanical area in univesity education (DUTRA e GULLICH, 2014.)

According to Luciene *et al.* (2015, p. 2), in graduation courses, the future teacher has to learn botany, in addition, he must learn to teach it. However, this often does not happen, a worrying factor when we observe that most of the courses that portray botany and teaching are degree courses. The author also reports that, in order to change this scenario, it is necessary for professors to be able to become their students in researchers and to increase their contact with the professional practice. Silva (2008) and Araújo (2011) argue that we should also consider the scientific environment and, specifically, Botany; that, based on technological advances associated with research, there is constant production of new knowledge; and this fact requires a continuous updating of the teacher, so that the contents are approached properly.

This concern with education in botany teaching is not something recent, we can see it in works such as Junqueira (2012, p. 25), in that he cites a compilation of authors who were concerned with botany teaching around the world, this is motivated by the fact that, unlike animals, the plant kingdom arouses little interest, since it is seen as something without life. And this leads us to another problem that Salantino and Buckeridge (2016, p. 178) portray very well, which is this inability to perceive plants as living beings and that are relevant to a healthy stay of humanity on earth, called “botany blindness”, a term that is in disuse nowadays. It is important that there is a break in this paradigm so that teachers can work on issues within the classes.

Botany is closely linked to everyday life and needs to be worked on so that the student is motivated and willing to participate in the classes, for this it does not get much, simple or

diversified classes can become interesting and help the student's understanding in relation to content (Bocki *et al*, 2011). However, in schools, the study of botany is limited only to content based on books due to the difficulty of demonstration and methodological innovations in the classroom; thus contributing to the lack of interest in content, which is of great importance to high school students. (RODRIGUES DE ALBUQUERQUE; ROSA DE LIMA JÚNIOR, 2019).

As a subarea of botany, plant physiology describes mechanisms involved in the absorption and transport of water and nutrients, in the biosynthesis and metabolism of reserves, in seed germination and in the development of a plant adjusted to its original environment (TAIZ *et al*, 2017). Not only for that reason, but also through the study of plant physiology, active principles for drugs and tools of our daily life were discovered, further highlighting the importance of teaching and understanding these subjects for students.

In a scientific work by Mattos (2019), the researcher tried to understand how the textbooks of schools in Rio Grande Sul present the contents of Botany, and concluded that, when dealing with plant physiology, the main subject addressed is plant hormones and that, in general, High School Biology books always place the contents in the middle or at the end, showing that these subjects are dealt to when there is time left in the school calendar. These results, together with those of Kawasaki and Bizzo (2000), who carried out a study in public and private schools, expose the students' lack of sensitivity regarding the importance of plant physiology and much of the information regarding other areas of plant physiology was left diffuse and/or ambiguous, being worked on separately.

During the emergency moment of covid-19, with new methodologies being developed fulltime, it is little known about how the impact of remote teaching affected the study of plant physiology, and what were the alternatives used by teachers to reduce this “gap” in teaching. With this in mind, in this work, the general objective was to identify the main methodologies used during the emergency period in Brazil.

METHODOLOGY

This research has a qualitative and quantitative perspective, being a systematic review, because, according to Galvão and Perreira (2014, p.138), systematic reviews are secondary studies, which have their data source in primary studies. It is a way of organizing and understanding research done on a topic. Furthermore, the current work was guided by the steps described by Barbosa *et al* (2018), where a protocol was created so as not to deviate from the proposed theme while the works were analyzed. The methodology is divided into the following steps:

a) construction of the protocol: Development of the protocol, in that we delimit the main and secondary questions, along with the exclusion and inclusion criteria. These inclusion questions are as follows:

- Was the work done during the pandemic time (2020-2022)?
- Did the work present the methodologies used by the authors to teach the classes?
- Were they easy to replicate?

b) definition of the question: the guiding question of this review is: “What were the most used methodologies during the pandemic time to help teach plant physiology?”

c) search for studies: the chosen studies were based on articles indexed in the following databases, Google Scholar and the annal of the 71st National Botanical Congress. To carry out the search, Boolean (AND and OR) and proximity (ASPAS) logical operators were used, assisting the keywords: Plant Physiology+Teaching, Teaching+Botany, Active Methodologies+Plant Physiology and Active Methodologies+Botany. These keywords underwent modifications, since when used, several materials appeared that were not relevant to the research, thus, the word “Pandemic” was added for more specific purposes.

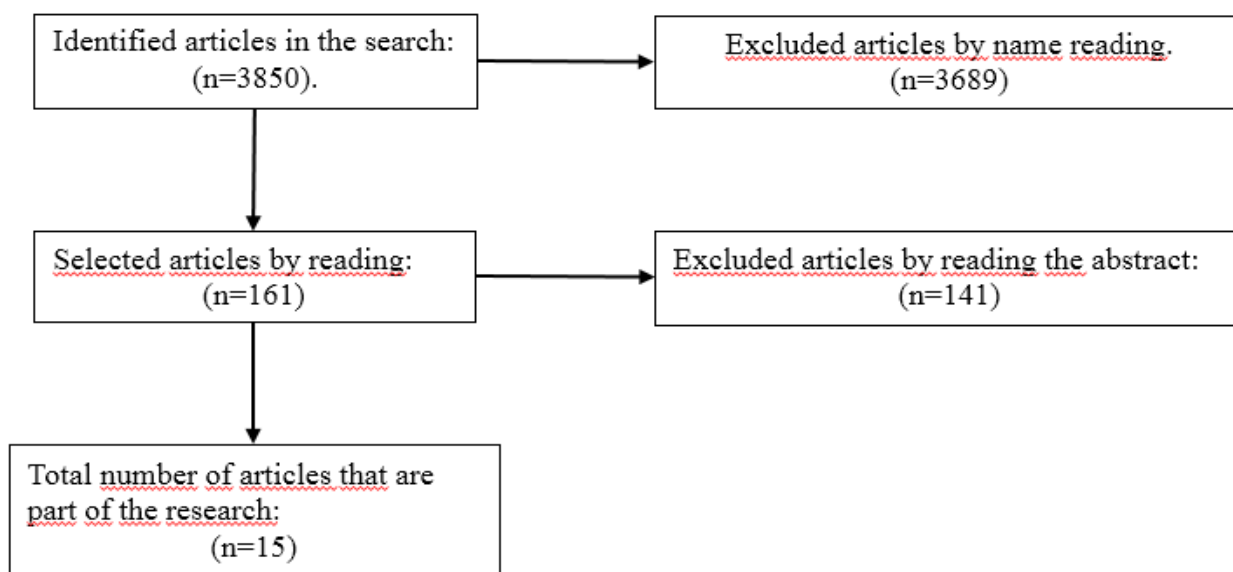
d) selection of studies: A temporal cut was carried out, in which the selected works were only articles that were developed in the remote teaching period until the present day, in the “post-pandemic” (2020-2022). As for the type of material collected, articles and abstracts were used. For the selection of works, a filtering was carried out, where the name was first read and then the abstract, after which the selected works were separated in a table using the Google Sheets software, removing information such as Name, Year and Methodology used. After reading the abstracts, publications whose contents were not directly related to the teaching of plant physiology were disregarded, such as: conservation of plant species, ecology of plant species, plant anatomy and morphology, etc. The Excel (2019) application software was used to transform the data into tables.

RESULTS

Considering all the keywords, we found a total of 3850 works, after reading the name, only 161 articles were left, of which the abstract was read and only 15 articles remained, which served as the basis for this review. In figure 1, it is exemplified in the form of an organization chart how the selection steps of the works were carried out. All 15 articles addressed the teaching of plant physiology during the pandemic and indicated the methodologies used by them.

Figure 1 :

Organization chart exemplifying the article selection process.

*Note: Own authorship*

The selected works were organized in a table (1), presenting in general all the academic productions found, as well as the methodologies used by them and the years of publication of each work.

TABLE 1:*Found Articles, Used Methodologies and Covered Topics.*

Found Articles.	Publication year	Used Methodology	Topics Covered
The proposal for an experimental class in Biology (Plant Physiology): Experiencing abiotic stress in corn plants (<i>Zea mays</i> L.)	2021	Experimenting with home materials.	Growth, Photosynthesis and Hormones.
Experiences and challenges in carrying out practical biology classes in the pandemic context.	2022	Experimentation and Dissection.	Transpiration, Photosynthesis and Pollination.
Modeling and 3D Printing of didactic tools for the Agronomy course.	2021	3D Models 3D	Physiology in general..

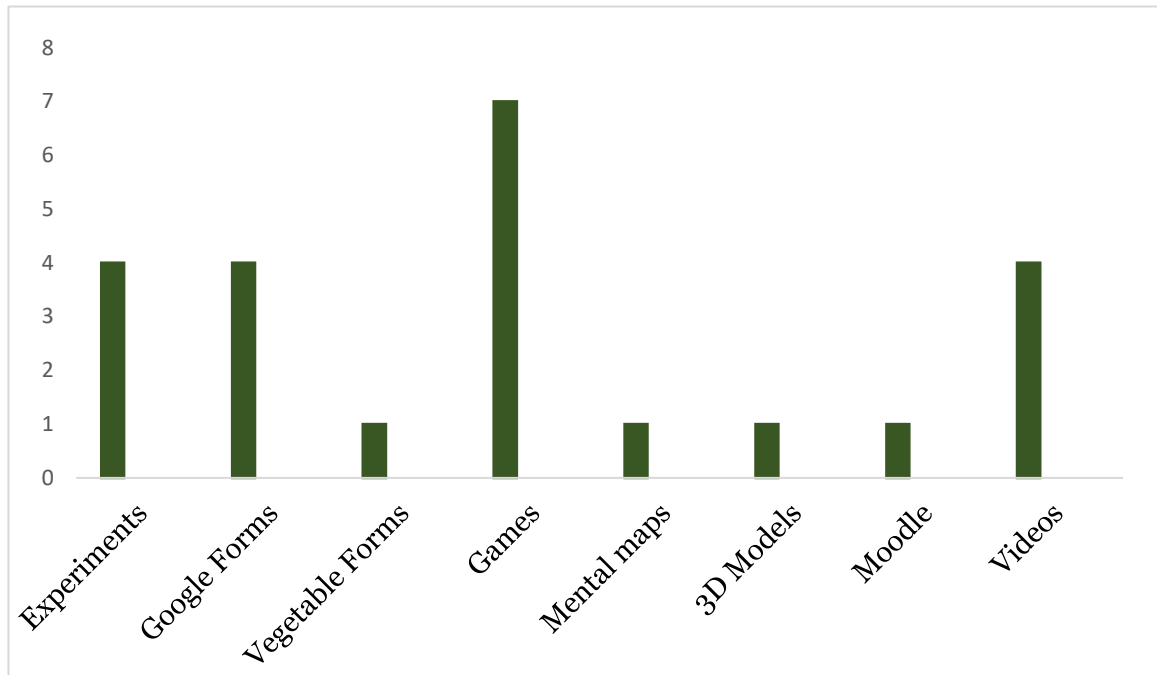
Found Articles.	Publication year	Used Methodology	Topics Covered
Practical class of plant physiology in remote teaching? Yes, it's possible.	2021	Planting seeds.	Growth, Photosynthesis and Hormones.
Pedagogical Residency, teaching and learning plant physiology	2021	Experiments, Quizzes and Videos.	Histology, Perspiration and Hormones.
Corn and bean seed viability and germination test: a proposal for an experimental Botany activity for High School.	2021	Experimentation and Plantation.	Growth, Photosynthesis and Hormones.
Use of multimedia materials in the conceptual approach to photosynthesis in remote teaching.	2022	Booklets and Quizzes	Photosynthesis.
“Fact or Fake?”: putting physiology knowledge into practice from the internet.	2021	Truth or lie game.	Germination and Flowering.
Playing NITROGEN HANG: a tool for teaching Plant Physiology.	2021	Hang game.	Nitrogen Fixation.
Audiovisual didactic material: “Can plants talk and move?”	2021	Audiovisual material.	Tropisms, Nasticisms, Communication, Tissue injury.
The exercise of remote tutoring and the challenges of teaching and learning plant physiology.	2021	Vertical garden and game “what is what”.	Physiology in general.

Found Articles.	Publication year	Used Methodology	Topics Covered
Plantation or Replantation: an alternative to test knowledge of plant physiology during remote teaching.	2021	Question and answer game entitled "Plant or replant"	Germination, Photomorphogenesis, Flowering and Phytomones.
Implementation of active methodologies as evaluative tools in the discipline of Plant Physiology in times of a pandemic: Experiences and challenges.	2021	Google Forms Concept Maps Kahoot and making short films Physiology in general.	Physiology in general.
Didactic strategies in remote teaching and living with google classroom in the pandemic.	2021	Moodle Classes and Google forms	Physiology of Angiosperms, plant tissues and plant organs and their morphologies.
Vegetal Bingo: a playful alternative for Remote Learning	2021	Online Game and Bingo.	Water Relations, Mineral Nutrition, Nodulation, Photosynthesis, Respiration and Translocation of Organic Solutes.

Note: Own authorship

All methodologies used by the authors were removed from this table and placed in figure 2, in order to better organize what was found. These methodologies were applied in the most diverse subjects and contexts.

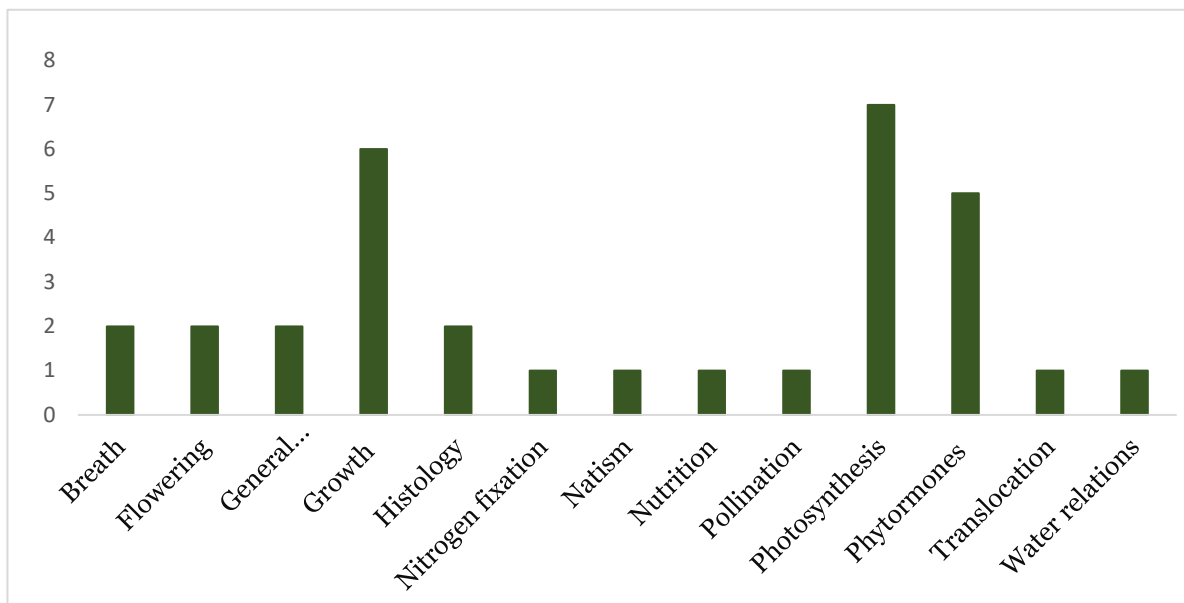
Figure 2:
Methodologies used by the authors



Nota: Own authorship

When it discuss about methodologies, the most used were games (with 7 works), soon after videos, experiments and finally Google forms (with 4 works each). These methodologies are also used during face-to-face teaching, being only modified for remote teaching. In Figure 3, we show the subjects most used by the authors in carrying out the active methodologies.

Figure3:
Most discussed contents



Note: Own authorship.

We observed that Photosynthesis is what stands out the most among the subjects addressed (7 articles), which corroborates the literature where it is mentioned that photosynthesis is one of the most complex subjects among those addressed in plant physiology classes. Soon after are Growth (6 articles) and Phytohormones (5 articles). This leads us to question the reason for this difference, since one subject leads to another. Among the smaller ones are Nutrition, Water Relations, Translocation, Pollination, Natism, and Nitrogen Fixation, present, each, in only 1 article. This shows how necessary it is to formulate new studies and methodologies capable of facilitating the understanding of each subject.

DISCUSSION

The teaching of botany is marked by the absence of teaching-learning practices (Menezes *et al*, 2008. p.1). This hinders the construction of knowledge by the student. Cruz *et al* (2016) portray that the study of plants aims at an interdisciplinary methodology, not just fragmented studies, such as Plant Morphology or Plant Physiology; because, like other living beings, plants do not live individually, plants participate in important ecological relationships, which are extremely important for the maintenance of life on earth.

Due to the pandemic time, that occurred in the first half of 2020, new teaching and learning strategies were adapted and tried out in basic education schools, as well as in higher education, face-to-face classes had to be replaced by remote classes, a greater challenge for teachers, who had to deal with the implementation of virtual rooms, which would be the possible alternative in the face of the situation. The application of new technologies in the classroom has become one of the main subjects discussed in recent years in the educational scope (LIMEIRA *et al*, 2020).

Among the found works, we had a large number of methodologies that were repeated, this may be due to their ease of replication, in addition to being, in a way, easy to do and, often, interesting to the student. The ones that stood out the most were the following: Games, Videos, Experiments and the use of Google Forms.

Games

In total, there were 7 articles that used games as a methodology during the pandemic, a high number compared to the others, but also self-explanatory, since this methodology is often simple and effective.

Games are very valuable elements in the knowledge appropriation process. They allow the development of skills in the field of communication, interpersonal relationships, leadership and teamwork, using the relationship between cooperation and competition in a training context within the classroom (BRASIL, 2006).

In one of their works, Campos *et al* (2002, p.48) argue:

In this perspective, the game gains space as the ideal learning tool, as it proposes to stimulate the student's interest, develop different levels of personal and social experience, help build their new discoveries, develop and enrich their personality, and symbolize a pedagogical instrument that takes the teacher to the condition of conductor, stimulator and evaluator of learning.

When we think about teaching plant physiology, games come as a light in the classroom, making the absorption of the subject simpler and more practical. From this, it is notable that the use of games in the study proves to be extremely useful, and is one of the methodologies where the student gets involved and manages to absorb all the content, as it also requires a better adaptation of the teacher to the studied context in classrooms.

Videos

Works with audiovisual materials totaled 4 and show how the creation of short videos and the use of some video lessons are and were functional during the pandemic period.

According to Santos *et al* (2020, p.2),

For teacher training, updating, questioning and constant evaluation of their pedagogical practices are essential, which includes technology resources. In this context, audiovisual resources are tools increasingly used in the classroom to make the teaching-learning process more dynamic and enjoyable.

In addition, we have to differentiate distance learning from audiovisual materials, since both are different from each other.

Videos help teachers and students a lot in their learning process, as the chosen themes are worked on in the classroom and students are involved in a creative and effective way in the classroom, but care must be taken with what material is chosen, preventing the material from dispersing them too much (PAZZINI E ARAUJO, 2013).

In this focus, it is observed that all works, which used videos and short films as active methodologies, obtained positive results in the teaching process, although many of the students, according to the authors who carried out the works, did not show much interest.

Experiments

Despite the pandemic scenario, practical classes involving some kind of experimentation are still necessary, as they bring the theoretical content closer to the studied reality, in an objective and clear way. In all, there were 4 works that talked about experimentation, and all focused on planting seeds and assembling dissecting specimens.

According to Sá and Lemos (2020), practical classes are fundamental in the teaching and learning process. When the teacher joins theory with practice, he is working not only on his students' learning, but also arousing curiosity for the subject being worked on, allowing them to interact during classes. Thus “In the teaching of biology, practical classes in laboratories are important research instruments, since they allow the student to experience problematized situations and experience the conceptualized theory in the classroom” (Interaminense, 2019, p.343).

Although the experimental activities were carried out remotely, this did not affect the students' knowledge of what was studied, on the contrary, it encouraged them to understand a little more about what was seen and increased the family bond, since the family was often present, assisting the student in the practices passed by the teacher during remote classes.

Google Forms

As it is one of the most used tools during the pandemic, the number of works that cited this methodology was relatively low (4), since Google Forms is a very versatile tool, which can be used at various times, since it allows us to collect data on the most diverse imposed variables, quickly and clearly.

Currently, technology has become present, standing out due to the pandemic, limiting communication only through digital means, especially in education. In this context, the use of digital resources by educational institutions has increased considerably; and, according to Sampaio and Alcântara (2018), such a digital resource is a tool for pedagogical innovation.

According to Nguyen (2018), Google Forms can and should be used in numerous ways to increase the benefits of the classroom environment, such as for research inside or outside the classroom, thus making it possible to better understand the individualities of each student. In the classroom, responses are collected during teaching; and, for extreme cases, the self-reflections generated after solving the lesson are collected.

Within the works seen, the use of this tool went far beyond the search for information only, it served as parameters and as a safe way to include the student within their home for the school context.

CONCLUSION

As it was seen, despite the difficulties, it was possible to do practical classes during emergency teaching, with the help of digital technologies. Classes that can be adapted to the face-to-face context and even distance learning in Brazil, and even if it is difficult to carry out these classes in our daily lives, simple activities such as those carried out by the authors found, show how important it is for the student's assimilation and appropriation with the that was studied, thus improving learning during a turbulent time of education in the country. And despite this, more studies are still needed that seek to create and test new methodologies on the teaching of plant physiology, in order to help all students who have some difficulty in studying it, which is so important in our lives.

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