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Non-Destructive and Non-Invasive Methods in Research on the Effects of Water and Ultra-High Dilution Preparations on Plants: An Overview

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Abstract

This article reviews part of the history of ultra-high dilution (UHD) research or homeopathy applied to plants and water. The scientific relationship between European and Brazilian groups has resulted in solid research, producing evidence that had not previously been proposed. Amidst this evolution, new technologies have emerged, and some are discussed here. This review emphasizes diagnostic experiments using low-power laser and cold plasma generated images. Both technologies are methods discussed to assess seed germination and identify beneficial effects of UHDs in plants and water.

Introduction

Agricultural ecosystems cause numerous impacts that are well known but insufficiently considered in decision-making or pertinent diagnoses. The utilization of water and soil, the quality of the food produced, and the risks to food safety continue to haunt the "scientific consciousness." Water is a scarce resource, and climate change directly affects plant production as the demand for irrigation increases. In 2019 alone, water consumed in Brazil for crop irrigation and animal use represented 66.1% and 11.6%, respectively, and consumption is expected to increase by another 26% by 2030 (Brazil, 2019).

Pollution of water sources in Brazil gets worse every year; the negative contributions of various chemical products that end up in the water result in a national distribution water loss index of approximately 36.7% – considering that certain pollutants are harmful to human health and are not included in the official list of substances for mandatory monitoring of drinking water (Hess, 2018).

UHD techniques have great potential as low-cost and viable technologies in the treatment of soil and plants to improve the use and management of potable water in agricultural environments, and as indicators of environmental quality in situations in which impacts are barely apparent or neglected. Aparicio *et al*. (2020) suggest the use of UHDs associated with solvatochromic dyes, which would function as "probes" or physicochemical markers for water samples obtained from water sources treated with UHDs, thus assisting in signaling optical changes in water, as well as possible changes in quality.

Scientific research on water and UHD in plants, from a global point of view, offers several modes of action and it was once dedicated to answering questions about the behavior of water in physical and biological systems through plant models (Miranda, 2008; Betti *et al*. 2008; Liu *et al*. 2013). Although knowledge in this field is gained in a fragmented way, it still presents significant converging results, highlighting the scientific importance of models based on plants. Moreover, despite the famous expression "all our models are wrong" they are still helpful (Wolkenhauer and Ullah, 2007; Posfai *et al*. 2021) and, unfortunately, often become part of the hostility towards homeopathy (Agathokleous *et al*. 2019).

Research into UHD of water and hundreds of substances applied to plants has led to numerous investigations throughout the 20th and 21st centuries. In general, progress has been advanced by various universities and institutes, some more dedicated than others. In any case, important scientific discovery has occurred. Work continues because of multidisciplinary teams such as the International Research Group on Very Low Dose and High Dilution Effects (GIRI - http://giri-society.org/) and the International Council for Homeopathy (ICH - http://www.homeopathy-ich.org/). Highlights in Europe are an Italian group (Brizzi *et al*. 2000; Betti *et al*. 2003 and others) and a Swiss group (Endler and Schulte, 1994; Wallatch *et al*. 1998 and others) dedicated to experimentation, modeling, and basic research of UHD, in several projects working with plants.

In Brazil, most homeopathy teaching and research institutions that have carried out studies that are applicable to plants have focused on crop yields in most agronomic aspects. In this regard, certain publications and institutions were chosen here to indicate the pioneering spirit in scientific dissemination, highlighting the continued work in research on homeopathy. In order of dedication and pioneering, it is important to highlight the Federal University of Viçosa – Casali *et al*. (2000). A few years later, the State University of Maringá – Bonato (2003) joined, followed by the partnership between the State University of Santa Catarina and the Agricultural Research and Extension Company in Santa Catarina – Boff *et al*. (2004). Shortly thereafter, Rossi *et al*. (2006), now a professor and researcher at the Federal University of São Paulo, started his research. Concomitantly, basic research has created a valuable branch of GIRI, which remains active today (Bonamin, 1998), with a strong influence from veterinary sciences.

Different studies confirm the existence of the effects of UHD and were published in high-impact journals during the first and second decade of the 21st century, such as the Scientific Reports (Kokornaczyk *et al*. 2020); Langmuir (Chikramane *et al*. 2012); J. Am. Chem. Society (Wei *et al*. 2013); Acta Scientiarum Agronomy (Giesel *et al*. 2017); Material Letters (Rao *et al*. 2008); J. Solution Chem. (Elia *et al*. 2008); Material Research Innovation (Roy *et al*. 2005); J. Thermal Analysis and Calorimetry (Elia and Nicoli, 2004); among numerous publications in dedicated journals such as Homeopathy and International Journal of High Dilution Research.

In this set of references, evidence of the effects of UHDs on plants was mounting as described by Bonfim and Casali (2012). Some of these experiments demonstrated the growth and crop yield of plants, which likely boosted the proliferation of research teams, which can be consulted in the "Directory of Research Groups of Brazil" with at least 16 groups registered and dedicated to the agronomic area.

The link between UHDs and plants encompasses different methodologies, generally based on the characterization of macroscopic response signals, with few studies investigating cellular, enzymatic, hormonal, or even genetic and metabolic expression levels (Dei and Bernadini, 2014; Teixeira and Carneiro, 2017). Perhaps the most innovative method, which offers a great opportunity in the study of UHDs in plants without the need for sophisticated and expensive equipment, is described in the work of Cartwright (2016, 2017, 2018, 2020) and Bonamin *et al*. (2020). These researchers suggest a role for water in propagating and maintaining the homeopathic signal, which would be extremely useful for laboratories dealing with homeopathic medicines.

Zanco *et al*. (2021) advocated another method with great potential to evaluate homeopathy. The proposal uses photonic sensors (low-power laser and cold plasma) to capture images of plant propagules in a non-destructive and non-invasive way. Next, it builds a computational vision representation to identify the signals of UHDs in plants and the environment. Consequently, the model shows two relevant advantages: (i) the conservation of research samples, which remain with the researcher for a long time, and (ii) the perspective of keeping a safe distance between the observer and his object of study.

That said, the purpose of this paper was to review potential non-destructive technologies that demonstrate the signaling of the UHD's effect in water and plants, especially on leaves and seeds.

Preliminary Survey on Scientific Article Platforms

The keywords "high dilutions," "homeopathy" and "speckle laser" – or "biospeckle laser" in the first search (*Scielo*, Scopus, IEEE, and ScienceDirect) – did not bring results. On the other hand, considering that research citations are repeated across search platforms, the term "laser speckle" showed 11 results in *Scielo*; 1,080 results in the

IEE; 3.251 on ScienceDirect, 4,982 on Scopus. The word "biospeckle" appears 11 times in the IEEE, 14 in *Scielo*, 99 on ScienceDirect, and 257 on Scopus.

On the other hand, the composite keyword "gas discharge visualization" showed only 20 results on ScienceDirect: 68 results in Scopus and 115 in IEEE. In addition, this term has another variation, *e.g.*, GDV, which, combined with the keywords of "water," "homeopathy" or "ultra-dilutions" are rare and in one of the listed articles, Kononenko *et al*. (2005), shows that the GDV measures, at least to some extent, the vitality of plants. In other more recent work, the authors obtained significant evidence from GDV to differentiate treatments performed on wheat crops (Kolesnikov *et al*. 2019).

Adding the keyword "non-destructive" to the title of the work and "laser" to the body of the text, 932 documents were found in ScienceDirect – one result using the term "laser biospeckle" and three in Scopus. Next, when searching in the body of the text, the same query presented 36 articles in Scopus between 1997 and 2021, and 180 documents with the term "laser biospeckle" from 1994 onwards.

Most of the publications found do not present significant advances on photonics applied to UHD and plants. This type of methodology has a high potential for permeation into several areas of knowledge, including the study of plants under the effect of ultra-diluted dynamized substances. And, considering the particularities of the research found, specifically the non-destructive photonic technologies, the advantages of non-destruction of the sample in long-term investigations are exceptional.

The Convergence of Research Groups in a Global Perspective

Since the 1980s, European research on UHDs has gained notoriety, and two groups have emerged in Italy and Switzerland, bringing together researchers in other countries. The papers discussed deal with issues relevant to understanding the progress of homeopathy, especially when applied to plants and the environment, in addition to issues related to human and animal health.

Some investigation into models with plants took place much earlier, in the 1920s. Although research has presented important findings that unfortunately garnered little interest in the current scientific community, questions about the signaling of homeopathy maintained a relevant place in academia. For example, the circadian effects of lunar luminosity and homeopathy seen in the work of Kolisko (1926) and Kolisko and Kolisco (1939) had their studies replicated years later by Graviou (1976), Pongratz (1993), Brizzi *et al*. (2000) and Bonato (2005). Another researcher that needs to be highlighted is Netien (1962), who presented the first investigation involving modern aspects of plant physiology when he addressed the activity of homeopathic dilutions in the respiration of maize coleoptiles. Others with their successful models tested the detoxification of $CuSO_4$ in plants using 15CH potencies (Netien *et al*. 1966), which were later successfully replicated by Auquiére and Moens (1981) at potencies of 14CH. It is interesting to note that the first homeopathic method was named by Christian Friedrich Samuel Hahnemann, the creator of homeopathy, in 1796. Since then, the Hahnemannian dilution consists of centesimal dilutions. Hence the Hahnemannian centesimal indication, abbreviated to CH, is mentioned on the labels of medicines thus prepared.

Scofield (1984) made a good review of the potential role of homeopathy in agriculture and has since highlighted the importance of statistical design for the proof of certain methods. Betti et al. (1994) proposed a pilot study involving plants as a model to explain homeopathy signaling. A few years later, Walach et al. (1998) presented a protocol for capturing signals from UHDs using the Electric Measurement Device (EMD). But he noticed that certain potencies were not distinguishable, in this case, between water and Natrium muriaticum in 30 CH. Moreover, Betti et al. (1997) found significant statistical effects on UHDs applied to wheat seedlings, proving their effects on arsenic detoxification. His research group early on realized the importance of involving different institutions to demonstrate the evidence that homeopathy expresses in plants, noting that the occurrence of contradictory effects is intricately tied to the scientific method used (Brizzi et al. 2000).

The effort to coordinate multidisciplinary research has positively impacted the evolution of plant homeopathy and helped to build the foundations of the different branches of research (medicine, veterinary and agronomy), now much more unified. This can be evidenced in publications concerning the propagation of plants in vitro and homeopathic products tested in field applications (Sukul and Sukul, 2005; Witt *et al*. 2007; Scherr *et al*. 2007; Betti *et al*. 2009; Bonfim and Casali, 2012; Yamab-

hai *et al*. 2013; Rodiuc, 2015; Trebbi *et al*. 2016; Barreto *et al*. 2016).

Interactions Between Water and Homeopathy

The behavior of homeopathy in water and in water transformed into homeopathy is distinct, with attributes widely disclosed in homeopathic pharmacopeia protocols. Although water is such an elementary part of homeopathic preparations, from processing to the final constitution of the product, there are few studies but much discussion. Among the theories that support the behavior of water under the effect of homeopathy, some include the term "water memory" and manage to present logical reasoning between quantum thinking and Avogadro's number as the limit of physicochemical reactions. In this sense, Henry (2017) presents innovative arguments that highlight the minimum necessary for the scientific discussion on water and homeopathy, where the "memory" dimension has a set of assumptions that bring together fields of science that have been competing so far (Tschulakow *et al*. 2005; Thomas, 2007; Elia *et al*. 2007).

According to Antonchenko and Ilyin (1992), after homeopathic succussion the water acquires new characteristics ("radiative") conditioned by the specific dissolved substance and the charged particles, always present in small amounts in water solutions, that do not show primary radiation, nor even conditions to form a powerful coherent radiation. But, due to the continuous presence of these substances, all homeopathic medicines are shown to contain their own radiation frequency spectrum. There is a connection between the many frequencies of homeopathic medicines and the existing water structures in the human organism. Furthermore, there is a probable existence of clusters of these structures that tend to spread throughout the available volume and fill it with similar structures throughout.

A few years later, Tschulakow *et al*. (2005) proposed a method that could better clarify this problem, supporting the concept of "water memory" and using photonics to explain this behavior. The collaboration of research groups between Brazil, the USA, Europe, and India produced a series of valuable successes and motivated research linked to homeopathy. GIRI plays a central role in this approach and has proposed starting more comprehensive studies with abiotically stressed plants (Jäger *et al*. 2011) and water (Mota *et al*. 2018), involving routine, systematic, negative control experiments to exclude false-positive results and with independent replications.

Currently, Maity and Mahata (2021) have addressed this issue through quantum electrodynamics, suggesting that serial dilutions with succussion in water carry information about the solute through specific aqueous structures of the solute. To confirm these characteristics, the authors used nuclear magnetic resonance spectroscopy, anomalous dielectric dispersion and atomic force microscopy and hypothesized that successive aqueous dilutions acquire altered structures with the impression of the starting material. Finally, they demonstrated that altered properties of UHD can be attributed to water structures, such as carbon allotropes, justifying water structures as potential carriers of information.

The sustainable use of water in the agricultural environment is crucial for the quality and cost of food. Homeopathy intervention can improve it technologically. Although water and its homeopathic modulations are of general interest, little research has been carried out in this field. In Brazil, Casali and Andrade (2012) carried out a series of experiments in this direction, reporting for the first time the pathogenesis of a series of homeopathic preparations covering different potencies in water and soil solution. The experiments carried out by the authors were important because they showed the effects caused by homeopathy in drinking water (pathogenesis) and the primary action of a homeopathic preparation. In this case, it showed statistical significance in the reduction of electrical conductivity, pH change, increase in turbidity and biochemical oxygen demand.

Non-Destructive Methods in Plant Research and Homeopathy

Several methodologies can be applied to the analysis of homeopathic signal patterns. Some methods are well known, although they have a relatively high cost when related to plants: ultrasound (Fariñas *et al*. 2020); infrared cameras (Parihar *et al*. 2021; Loukatos *et al*. 2021); Raman spectroscopy (Sharma *et al*. 2021); magnetic resonance (Borisjuk *et al*. 2012); X-ray (de Medeiros *et al*. 2020); electromagnetic ultrasonic (Huang and Wang, 2016); hyperspectral reflectance (Zang *et al*. 2020), among others (Xia *et al*. 2019). When associated with non-destructive technologies, they can accurately re-

flect state variables of physical systems (*e.g.*, water and UHDs) and biological systems (*e.g.*, leaves and seeds).

Zanco *et al*. (2021) developed a prototype for the analysis of homeopathy effects in plants using alternative, non-invasive materials and tools, resorting to photonics: speckle laser (SL) and cold plasma (GDV – gas discharge visualization), using well-known image analysis techniques from "computer vision", from tests with algorithms implemented in numerical methods (time history speckle pattern – THSP), graphic methods (generalized differences – GD and Fuji algorithm) and frequency analysis methods (Vibraimage Software® – VI).

In another prototype, infrared thermography and low power lasers were used. To assist in capturing information, computer vision was applied to the acquired images, which were supported by specific algorithms built in the Vibraimage® software (Minkin and Nikolaenko, 2008; Zanco *et al*. 2021).

The first publication on "speckle laser" deals precisely with low-power lasers for analyzing objects from images or speckles generated by the capture system, based on experiments in physics of materials by Stetson (1970), when the author used the term "laser image-speckle" for the first time. After that, a series of works were published, and certain researchers improved this image capture model, investing in biological studies, with the terminology "biospeckle laser (BSL)", defined by Aizu and Asakura (1991), in blood flow analysis.

The laser speckle phenomenon has been well known since the days of printed photographs. According to Francon (1979): "...when a laser illuminates an object, it appears to be covered by a very fine granular structure, and all points of the object illuminated by the laser form coherent patterns... the waves transmitted to the human eye are subject to this interference... therefore, diffraction images are responsible for the granular structure known as speckle... If a photographic system replaces the eye, the phenomenon is the same: the image is shown to exhibit a pattern of spots that depends on the aperture of the lens...."

The model developed for the use of images generated by cold plasma, on the other hand, has its history confused with pseudoscience. The first images generated with plasma to become popular were developed using photographic films and called "Kirlian photographs" in honor of the Russian inventor of an apparatus that captured the images. However, the method proved to be inefficient due to a very low signal-to-noise ratio, making repeatability in the classification of images even more difficult. These difficulties made the system the target of numerous interpretations, reaching extremes that compared the plasma coronas generated by the apparatus to spiritual phenomena and auras of psychic energy, with no scientific basis whatsoever (Zanco, 2016; Domingues, 2021). Even so, the research evolved with the appearance of a device like a "scanner" that captured the generated plasma around objects, patented by Shtam *et al*. (1999) and called "gas discharge visualization (GDV)." The images produced by this device exhibited unique light patterns and met the rigors of mathematical analysis. The results were promising, including the first attempt to identify patterns in UHDs (Bell *et al*. 2003).

In a recent study, Zanco *et al*. (2021) compared the performance of technologies, which proved to be viable to inform UHD signals in plants. The technologies, BSL and GDV, generate images with different patterns and are robust for different types of analyses. The use of traditional mathematical methods and known algorithms from computer vision were important to identify the patterns generated by the plasma images and validate the scientific use of the devices. (Hetzroni *et al*. 1994; Korotkov *et al*. 2005).

Laser research involving water may involve the development of mobile devices that are easily adapted to field conditions and yield real-time data. A prototype named "portable laser biospeckle" was introduced by Botega *et al*. (2010) to monitor the behavior of water in coffee leaves. This degree of innovation has immense potential to identify different behaviors when observing plants under the influence of ultra-diluted or homeopathic substances. At the same time, laser emission from water or liquid UHD samples has always been a challenge as to processing data, facing the large number of images, and considering the low signal-to-noise ratio. In this case, the better solution is to generate discretized images and forgo videos due to the size of the files and the great effort in digital processing. Alves *et al*. (2013) were able to indirectly measure water activity in carrot samples, linking it to a specific phenomenon, such as respiration. And the results obtained in the research by Zanco *et al*. (2021) were consistent with the use of this methodology. These authors analyzed effects on seeds treated and not treated with

homeopathy, obtaining significant differences between the two cohorts, the potential dilutions used (6, 12, 30 CH), and the liquid substances containing *Silicea terra* and *Bryonia alba.*

The use of cold plasma and laser in biological diagnosis and treatments is well discussed by Popp and Beloussov (2003), who cite several studies that organize the use of the term "biophoton" in a broader sense, evidencing the optical transparency of biological tissue and electrodynamics, quantum mechanics of cavities in optically dense tissues, suggesting that an interaction occurs with the vacuum by forming cavities and thus creating special coherence effects: *"The solid part of the organism is coupled with a highly coherent, holographic biophoton field which is proposed to be the basis of communication on all levels of organization"* (Popp and Beloussov, 2003, p. 72).

The identification of signals in plants under the effect of homeopathy is not yet a reality. What is already available is stereo vision and laser scanning equipment to detect and classify structural characteristics of plants as well as to assess the vegetative distribution within the shoots and perform analysis that allow timely decision-making. Although we have current technologies with recognized advances, the costs for manufacturing and maintenance are still high. Low-cost innovations usually happen when patents expire. Some examples occur in the use of plasma and laser, in induced fluorescence, hyperspectral measurements, radiative transfer modeling and others (Langensiepen *et al*. 2020). At the same time, this integration with computer vision finds use in research projects on the homeopathy-plant-water relationship (Zanco *et al*. 2021). Perhaps, in the not-too-distant future, these promising technologies will help us to interpret with more clarity the effects of homeopathic products on the eco-physiology and metabolism of plants.

Computer Vision: An Innovative Tool for Research

Publications referring to non-destructive methods are widespread and well accepted when the subject is image analysis and are closely related to advances in computer vision and deep learning (Dana, 2018). These technological advances are the tools that can make deepening the study of ultra-dilutions, water, and plant seeds under different conditions even more feasible, especially concerning information where the human senses do not have sufficient sensitivity (Sutton and Punja, 2017; Zanco *et al*. 2021).

The advantage of using biospeckle lasers (BSL) to analyze UHDs, water and plants, refers to laser light propagation, which produces directional beams of highly coherent monochromatic light. The laser, or light energy, has an active (gas, liquid or solid) medium contained between parallel reflectors, which make light traverse forth through the medium, causing intensity to gain coherently with each move through the excited, meta-stable lasing material. This process is called "stimulated emission." Thus, when light is physically reflected by an object (water, seeds, leaves, UHDs), it emits minimal coherence and large spectral variability. The energy of light refers to photon energy, which remains the same for a given wavelength. During the lasing process, more and more photons (of identical energy) are accumulated, resulting in higher light intensity (more lumens). This provides opportunities to make inferences about the object from the extraction of numerical data from the laser scattering on the surface (Rabal and Braga, 2009).

Conventional water analysis equipment is expensive to purchase and operate. With moderate investments, use of alternative equipment such as GDV and BSL may help make access to information faster and more accurate. The "refractive indices" of water were measured quickly and accurately with laser (Trivedi *et al*. 2019) and plasma methods (Korotkov *et al*. 2004; 2019). Thus, in the same way, UHDs can also be measured directly or indirectly, for example, by monitoring and identifying the behavior of plants in a field subjected to UHD treatments. This would be transformative for the agronomic management of homeopathic products in real time (Zanco *et al*. 2021; Qian *et al*. 2021).

From the information shared in this review, it is reasonable to conclude that pattern recognition through photonic technologies can generate significant research for homeopathic science. Analysis of the effects of UHDs on plants and water presents great potential, together with the general diagnostic use of photonic technologies. But what is the fundamental aspect of the experimental model? From the current perspective, it seems to support anything that has to do with the temporal and spatial variation of the laser spot or plasma image around objects – so much so that the best elucidation of the diagnostic use of BSL and GDV employs sequential image analysis and dynamic simulation, which demonstrate biological activity and, thus, increase the control obtained experimen-

tally over a short period of time, without destroying the original sample (Kawamura *et al*. 2010; Alves *et al*. 2013; Zong *et al*. 2014; Cardoso and Braga, 2014; Rivera *et al*. 2019; Kolesnikov *et al*. 2019; Zanco *et al*. 2021).

Conclusions

The publications available to the scientific community represent a small window to the public, but also indicate the need for a solid scientific foundation for homeopathy. It is critical to recognize that the statistical methods adopted in journals that disseminate knowledge are legitimate. They commit to the truth and can demonstrate the evolution and importance of homeopathy in the larger endeavor of furthering human knowledge.

In the current state of knowledge about homeopathy in plants, evidence points to electromagnetic models at the cellular, metabolic and quantum levels. When establishing correlations between homeopathic dilution and physicochemical dilution, the premises do not lead to any logical conclusion – but neither do they contradict basic scientific paradigms, since the scientific community has not presented any evidence of correlations between Avogadro's constant and homeopathic ultra-dilution. Avogadro's evidence exists only for chemical-physical situations without the succussion event (Kokornaczyk *et al*. 2014; 2020). Most of the research results cited here confirm independence in the theoretical foundations of homeopathy and pharmacology – that, therefore, have no relation to drug concentration.

Water plays a key role in the sustainability of agricultural production environments and is essential for the quality of homeopathic medicines. Although it presents dozens of anomalies, which makes certain studies related to homeopathy difficult, water as a molecule continues to be studied in greater depth each year. The convergences of investigative fields have an immeasurable potential for aggregating research with diverse objectives. Here opens a magnificent heuristic opportunity that involves studying and developing homeopathic thinking applicable to plants, water, and the environment.

Non-destructive and non-invasive technologies, provided they are used correctly, greatly favor models for collecting water samples from soil and plants. If the sample has a statistically significant size, contains relevant information, and remains intact, the chances of explaining certain phenomena are much greater. Some sensors are efficient, widely used, and low cost, enabling their incorporation into systems with different goals.

In this review, we highlight two devices, the GDV and the BLS, which combine various aspects of science related to (i) water and the environment, (ii) homeopathy, and (iii) the effect of homeopathy on water. Any of these topics has a potentially unifying effect on research development. But the difficulty in this area of investigation is finding suitable methods that show physical, electrochemical, electromagnetic or quantum signals related to homeopathic potency – something that indicates when a signal or state change occurs. At what point does water or homeopathy express this transition?

The use of biophotonic apparatus on laboratory benches is widespread, and the devices support real-time data acquisition. However, their limitations are still in the monetary realm and options are limited. Alternative equipment can meet this demand but need validation to apply to regular research in the homeopathy area. The use of GDV and BSL brings together adequate technical characteristics to identify homeopathic signals. At the current stage of knowledge about these technologies, regardless of homeopathic potencies and water attributes, these are tools that will bring advanced solutions to this realm of research (Popp and Beloussov, 2003; Zanco *et al*. 2021). Mastering the art or science of using a particular homeopathic potency replacing or contributing to an allopathic medicine will represent a fundamental transformation for society and the environment.

Discussion with Reviewers (DWR)

Reviewer: The mode of effective action of homeopathic preparations applied to living organisms, including plants, is based on the descriptive similar state (organism and remedy), through reaction of the vital power (entity) of the sick organism to the remedy, leading to homeostasis or, in other words, to a cure. Could the biphotonic methods (low-power laser and cold plasma) assess the similarity state of both sick organisms and homeopathic products to give us the clue about how they could match under the cure law of similia similibus curantur? If that is the case, how could we see the level of similarity between them?

Authors: Photonic methods (low-power laser and cold plasma) can assess the similarity status of both sick organisms and homeopathic products. In this regard, methodological proposals were made by Kokornaczyk

et al. (2014, 2021), Zanco (2016), Zanco *et al*. (2021) and Domingues (2021) who claim that it is possible to identify signs of homeopathy, individually, as well as signs of homeopathy in plants from the contact of UHDs with tissues or protoplasm cell. However, the methods require classification relative to similarity, which demands a greater number of predictive experiments. In all cases, it is recognized that the method for identifying signals works and can be applied through "cold plasma" and "low-power laser" sensors. One possibility to validate the similarity would be to represent the signal value in a quali-quantitative way and observe plant behavior and then classify the values with the help of artificial intelligence applied to the image analysis.

Reviewer: Most conventional methods that could indicate the performance of plants in terms of agronomic properties are limited to the physiological state that is the result of the plant's genetic expression. What are the potential insights that the photonic methods (non-destructive and non-invasive) could provide to help the researcher and/or farmer in optimal decision-making?

Author: Conventional methods are important to validate the predictive methods proposed here. When the plant responds to stress, certain enzymes, hormones, and other substances can be analyzed and often demonstrate the physiological and phytosanitary status of the plant (Tzipilevich *et al*. 2021). However, the methods for obtaining this feedback have operational and monetary costs that are not feasible for most research programs. An alternative to reduce these costs is the use of signal measurement systems specific to the drug and the reaction of the plants. These signals can be read with the aid of computer vision and calibrated based on measurement models widely accepted by the scientific academic environment. A useful predictive measurement system immediately identifies the plant's reaction to the application of a particular medicine and the properties of the homeopathy being applied, even before visual symptoms occur or after the application of UHD. It is a system that can be transformed into a diagnostic model, capable of predicting the reaction of a plant to a drug or measuring the quality of the drug. A system whose greatest strategic advantage is the improvement or replacement of field management (Kokornaczyk *et al*. 2014; Zanco *et al*. 2021; Singh, 2021).

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