Effects of homeopathic high dilutions on plants: literature review

Marcus Zulian Teixeira¹; Solange M.T.P.G. Carneiro²

Abstract

Background: Among the non-conventional assumptions of homeopathy, the use of medicines in high dilutions (HD) is a cause for objections and skepticism among the scientific community, trained within the dose-dependency paradigm of classic pharmacology. Research aiming at evidencing the effects of homeopathic HD has resource to several experimental models (in vitro, plants and animals). Aim: To describe the results of studies with high methodological quality that demonstrated positive effects of homeopathic HD on plants. Methods: Taking reviews published until 2015 as reference source, we updated the information through addition of data from recent studies included in database PubMed. Results: From 167 experimental studies analyzed, 48 met the minimum criteria of methodological quality, from which 29 detected specific effects of homeopathic high dilutions on plants through comparison to adequate controls. Conclusions: Despite the substandard methodological quality of most experiments, studies with systematic use of negative controls and reproducibility demonstrated significant indisputable effects of homeopathic HD on plants.

Keywords

Homeopathy; High dilutions; Agriculture; Plants; Phytopathological models; Review
Introduction

Since homeopathic treatment is grounded on non-conventional assumptions (therapeutic similitude, pathogenetic investigation of medicines on healthy individuals and use of highly diluted and agitated medicines selected according to the full set of characteristic symptoms and signs of patients) its acceptance is resisted by the medical and scientific community, which ignores its specificities and the evidences that support it [1,2]. Used to large and increasing doses that have contrary and palliative action relative to the manifestations of disease, doctors and investigators do not consider the application of a treatment based on infinitesimal or minimal doses of medicines that cause similar disorders to the ones to be cured. This even though they do consider the advances of research in immunotherapy and nanotherapy, based on grounds similars to the ones of homeopathy.

Among the homeopathic assumptions, use of serially diluted and agitated medicines (potencies, high dilutions – HD) with concentration less than 1 gram-molecule (above Avogadro’s number, 6.02 x 10^{-23}) is the reason for the greatest criticism among skeptics, who adhere to the dose-dependent model of modern pharmacology. Denying any plausible effect to homeopathic HD in living beings [3,4], critics attribute the patent improvements induced by homeopathic treatment to the patient-doctor relationship and placebo effect.

To evidence the efficacy of homeopathic medicines in the treatment of diseases and the effectiveness of HD in biological systems, clinical and experimental studies are conducted with human beings, animals, plants, cell cultures, etc. In the present review we describe scientific evidences for the effect of homeopathic HD on plants found in the past decades.

By comparison to other types of studies, research on plants has countless advantages such as: large sample size; large datasets; short duration; low cost; absence of placebo effect; and absence of the ethical issues that apply to animal and human research. However, there are some disadvantages too: systematic pathogenetic trials of medicines have not been conducted with plants that would result in a homeopathic materia medica specific for plants, necessary for the selection of individualized medicines for each plant species and disease type, as we have asserted all along the past decade [5-8]. Then, some relevant parameters or artifact cannot be controlled, which interfere with the development and health of plants and hinder the reproducibility of experiments.

Studies assessing the effect of homeopathic HD on plants are known since 1926 [9]; the first literature review was published in 1984 [10]. Several reviews described the effects of homeopathic medicines on plants [11-16] and analyzed the factors related with improvement of the methodological quality of experiments and corresponding publications (detailed description of experiments, randomization, blinding, control group, statistical analysis of results, systematic use of negative controls and reproducibility, among others).

It should be noticed that systematic use of negative controls (placebo group not subjected to any other intervention) is the ideal method to ensure the stability of a system, exclude false-positive results and assess the specific effect of HD [16]. Reproducibility excludes false-positive results, thus ensuring the scientific quality of experiments [14-17]. As a result of the efforts to improve the methodological quality of
studies, the number of articles on homeopathic fundamental research in peer-reviewed journals considerably increased in the past 2 decades [18], being an indirect indicator of improvement in the experiments.

In the 3 main reviews that analyzed the use of homeopathic medicines in plants [11-13] the experimental results were clustered into 3 groups: a) models using healthy plants [11] useful to investigate issues related with homeopathic potencies and to perform homeopathic pathogenetic trials; b) phytopathological models [12] which are ideal to study the use of homeopathy for management of plant diseases and pests, which is allowed for and used in organic agriculture (agrohomeopathy) [12]; and c) models using plants subjected to abiotic stress (mineral toxicity, salinity, pH, etc.) [13] in which HD of the same stressors are used to re-establish the plants’ health.

As mentioned above, the lack of a homeopathic materia medica specific for plants including a large number of signs and symptoms in different species does not allow for the application of the therapeutic similitude principle, and consequently for individualized treatment of diseases and other disorders of plants. In addition to empirical application of homeopathic medicines to various plant disorders, studies evidence the efficacy of biotherapy or isotherapy (therapeutic identity principle) for management of diseases and mineral and chemical imbalance through administration of HD of the biotic (viruses, fungi, bacteria, insects, pests, etc.) and abiotic (toxic agents, NaCl, etc.) stressors that cause such disorders to neutralize them [16-20].

The main aim of the present review was to describe studies that evidenced effects of homeopathic HD on plants, which were clustered in tables according to the 3-group classification mentioned above. Then, based on criteria for methodological quality, we described the most significant experiments and lines of research, including some pursued in Brazil.

Materials and methods

The sources for information on the studies included in the present review were the aforementioned reviews [11-16]. The experiments with the highest methodological quality (Manuscript Information Score – MIS ≥ 5) published from 1979 onward were selected. Since the 3 previous reviews analyzed articles published from 1920 to 2015, to update the dataset we added studies published from 2015 to 2017 located through a search in database PubMed using keywords “homeopathy” AND “plant”; “homeopathy” and “agriculture”. We also described some Brazilian initiatives for homeopathic research on plants.

Results

The articles that met the inclusion criterion (MIS ≥ 5) were clustered into 3 main groups (healthy plants, phytopathological and abiotic stress). The corresponding data were synthesized and described in individual tables.
Table 1. Main studies on the effect of homeopathic high dilutions on healthy plants

<table>
<thead>
<tr>
<th>Author; year</th>
<th>Species</th>
<th>Aim</th>
<th>Parameters</th>
<th>Treatment</th>
<th>Control</th>
<th>Frequency and mode of application</th>
<th>Effects</th>
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</thead>
<tbody>
<tr>
<td>Endler et al., 2015 [21]</td>
<td>Wheat</td>
<td>Effect of gibberellic acid in HD on seedling growth in autumn vs. winter-spring</td>
<td>Stalk length</td>
<td>Gibberellic acid 30x</td>
<td>Water; potentized water</td>
<td>Treatments applied to Petri dishes containing seeds</td>
<td>In all autumn experiments gibberellic acid 30x reduced** seedling growth. Results for winter-spring were inconsistent</td>
</tr>
<tr>
<td>Majewsky et al., 2014 [22]</td>
<td>Gibbous duckweed (Lemna gibba)</td>
<td>Effect of gibberellic acid in HD on seedling growth</td>
<td>Growth rate</td>
<td>Gibberellic acid 14x to 30x</td>
<td>Water; potentized water</td>
<td>Seedlings were kept in Becker glass with nutritive solution and 1 treatment</td>
<td>Increase** of the growth rate with some HD; the plant developmental stage seems to influence response to treatment</td>
</tr>
<tr>
<td>Hribar-Marko et al., 2013 [23]</td>
<td>Wheat</td>
<td>Whether seed pre-treatment with gibberellic acid in molecular dose increases the effect of gibberellic acid in HD on seedling growth</td>
<td>Seedling length</td>
<td>Seeds were pre-treated with gibberellic acid in molecular dose (10^-5, 10^-4, 10^-3); treatment with gibberellic acid 30x</td>
<td>Water; potentized water</td>
<td>Application of 2 ml of pre-treatment in Petri dishes containing seed; 4 h later, application of 4 ml of treatments</td>
<td>In the group pre-treated with water gibberellic acid 30x reduced** seedling growth. In the groups given gibberellic acid in molecular dose, the lower the concentration the greater the effect of HD to reduce seedling growth</td>
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<tr>
<td>Kiefer et al., 2012 [24]</td>
<td>Wheat</td>
<td>Effect of gibberellic acid in HD on seed germination</td>
<td>Winter wheat seeds</td>
<td>Gibberellic acid 30x</td>
<td>Water; potentized water</td>
<td>Treatments applied to Petri dishes containing seeds</td>
<td>Gibberellic acid 30x reduced** the germination rate in the 2009-2010 experiments; no difference in 2011. This divergence might be due to poorer seed viability and season of the year</td>
</tr>
<tr>
<td>Endler et al., 2011 [25]</td>
<td>Wheat</td>
<td>Effect of gibberellic acid in HD on seedling growth in different seasons of the year</td>
<td>Seedling length</td>
<td>Gibberellic acid 30x</td>
<td>Water; potentized water</td>
<td>Treatments were applied to Petri dishes containing seeds</td>
<td>Gibberellic acid 30x reduced** seedling growth. Best effect in autumn. Causes for difference</td>
</tr>
<tr>
<td>Authors</td>
<td>Species</td>
<td>Treatment</td>
<td>Response</td>
<td>Notes</td>
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<tr>
<td>Pfleger et al., 2011 [26]</td>
<td>Wheat</td>
<td>Effect of gibberellic acid in HD on seedling growth</td>
<td>Seedling length</td>
<td>Gibberellic acid 30x</td>
<td>Water; potentized water</td>
<td>Treatments were applied to Petri dishes containing seeds</td>
<td>Gibberellic acid reduced** seedling growth</td>
</tr>
<tr>
<td>Santos et al., 2011 [27]</td>
<td>Vernonia grattissima</td>
<td>Effect of Phosphorus on plant growth and essential oil concentration</td>
<td>Growth parameters and essential oil content</td>
<td>Phosphorus 5cH, 6cH, 9cH, 12cH, 15cH, 18cH, 21cH, 24cH, 27cH, 30cH</td>
<td>Water; hydroalcoholic solution</td>
<td>Treatments applied 3 times per week, 100 ml per vase, along 3 months</td>
<td>Some HD, especially 9cH, increased** plant height and branch and leave dry mass; increased essential oil production</td>
</tr>
<tr>
<td>Scherr et al., 2009 [28]</td>
<td>Gibbous duckwee (Lemna gibba)</td>
<td>Influence of HD</td>
<td>Growth rate</td>
<td>Gibberellic acid, Argentum nitricum, kinetin and Lemna minor</td>
<td>Water; potentized water</td>
<td>Plants selected per similar number of leaves and size; kept in Becker glass with treatments</td>
<td>Gibberellic acid 15d, 17x, 18x, 23x and 24x reduced** growth rate</td>
</tr>
<tr>
<td>Sukul et al., 2009 [29]</td>
<td>Lady’s finger</td>
<td>Influence of plant regulators (CCC, chlorocholine chloride; MH, maleic hydrazide) on plant development</td>
<td>Growth and physiologic variables</td>
<td>CCC 30c, CCC 200c, CCC (with copper nanoparticles) 30c and MH 30</td>
<td>Potentized hydroalcoholic solution</td>
<td>Leave spraying of treatment diluted 1:550, twice per day, 2 days</td>
<td>All treatments increased** plant growth, chlorophyll content, protein and water amount in leaves; CCC30c with copper nanoparticles was more effective than CCC30c</td>
</tr>
<tr>
<td>Baumgarter et al., 2008 [30]</td>
<td>Dwarf pea</td>
<td>Effect of gibberellic acid in HD on seedling growth</td>
<td>Shoot length</td>
<td>Gibberellic acid 17x and 18x</td>
<td>Water; potentized water</td>
<td>Seeds immersed into treatments 24 h</td>
<td>Gibberellic acid 17x enhanced** growth of seeds harvested in 1997</td>
</tr>
<tr>
<td>Sukul et al., 2008 [31]</td>
<td>Pigeon pea</td>
<td>Effects on plant growth</td>
<td>Growth and physiologic variables</td>
<td>CCC 30c, CCC 200c, CCC (with copper nanoparticles) 30c and MH 30</td>
<td>Potentized hydroalcoholic solution</td>
<td>Leave spraying of treatment diluted 1:550, 8 days</td>
<td>All treatments increased** plant growth, chlorophyll, protein and sugar content</td>
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<tr>
<td>Authors</td>
<td>Species</td>
<td>Study</td>
<td>Treatment</td>
<td>Results</td>
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<td>Scherr et al., 2007</td>
<td><em>Lemna gibba</em></td>
<td>Effects of HD on growth rate</td>
<td>Growth rate, water; potentized water</td>
<td>Homogeneous plants (number of leaves and size) were placed in Becker glass with nutritive solution; then 46.2 ml of treatments were added</td>
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<tr>
<td>Baumgartner et al., 2004</td>
<td>Dwarf pea</td>
<td>Effect of plant hormones in HD on seedling growth</td>
<td>Gibberellic acid, kinetin, auxin, abscisic acid 12x to 30x</td>
<td>Gibberellic acid increased seedling growth</td>
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<tr>
<td>Chapman 2004</td>
<td>Lettuce</td>
<td>Effect of homeopathic medicines on plant growth</td>
<td>Sulphur and Silicea in HD</td>
<td>Silicea and Sulphur 1LM influenced plant development</td>
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<tr>
<td>Andrade et al., 2001</td>
<td><em>Justicia pectoralis</em> Jacq</td>
<td>Effect of HD on J. pectoralis growth, coumarin production and electromagnetic field</td>
<td>J. pectoralis, coumarin, guaico, Phosphorus, Sulphur, Arnica montana, humic acid 3cH</td>
<td>J. pectoralis, humic acid, Arnica Sulphur and Phosphorus 3cH improved coumarin yield</td>
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<tr>
<td>Brizzi et al., 2000</td>
<td>Wheat</td>
<td>Effect of Arsenicum album on seed germination</td>
<td>Arsenicum album (As₂O₃) 23x to 45x</td>
<td>HD 30d, 35x, 40x, 42x, 45x enhanced seed germination</td>
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<td>Betti et al., 1994</td>
<td>Wheat</td>
<td>Effect of Arsenicum album on germination</td>
<td>Arsenicum album (As₂O₃) 23x, 25x, 30x, 35x, 40x, 45x</td>
<td>HDs 40x and 45x improved seed germination</td>
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<tr>
<td>Pongratz &amp; Endler, 1994</td>
<td>Wheat</td>
<td>Effect of silver nitrate in HD on germination and seedling development</td>
<td>Silver nitrate 24x</td>
<td>Silver nitrate 24x enhanced seedling development</td>
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<tr>
<td>Endler &amp; Pongratz, 1991</td>
<td>African violet</td>
<td>Effect of indole butyric acid on plant development</td>
<td>Indole butyric acid 33x</td>
<td>Enhanced rooting</td>
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</tbody>
</table>
**Table 2. Main studies on the effect of homeopathic high dilutions on phytopathological models**

<table>
<thead>
<tr>
<th>Author; year</th>
<th>Species</th>
<th>Aims</th>
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<th>Treatment</th>
<th>Controls</th>
<th>Frequency and mode of application</th>
<th>Effects</th>
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</thead>
<tbody>
<tr>
<td>Shah-Rossi et al., 2009 [42]</td>
<td>Arabidopsis thaliana</td>
<td>Effect of HD on plants infected with Pseudomonas syringae</td>
<td>Infection rate of leaves 30 substances 30x</td>
<td>Water; potentized water</td>
<td>Plants fully plunged upside-down for 30 sec into 20 ml of treatments; 1.5 ml of dipping solution dropped onto center of each plant rosette from which leaked into soil, the remainder was added to irrigation solution</td>
<td>Biplantol reduced infection**</td>
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</tr>
<tr>
<td>Datta, 2006 [43]</td>
<td>Mulberry</td>
<td>Effect of Cina maritima on root-knot disease of mulberry</td>
<td>Growth and infection variables Cina 200c and Cina MT before and after inoculation 90% hydroalcoholic solution</td>
<td>Plants were sprayed 4 times, every 3 days, with 10 ml of treatment; Cina MT diluted 1:40 and Cina 200c 1:20</td>
<td>Treatments increased** length and fresh weight of branches and roots, number of leaves/plant and foliar area; and reduced** gall number/plant; treatment before inoculation was more efficacious</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Sukul et al., 2006 [44]**

**Lady’s finger**

Effect of homeopathic medicines on plants infected with nematode *Meloidogyne incognita*

Root gall number and nematode population

*Cina* 30c, *Santonin* 30c

Water; hydroalcoholic solution 30c

Spraying for 10 days, starting 7 days after inoculation. Each plant received 5-10 ml of treatment diluted in water 1:1000

Treatments reduced** root gall number and nematode population; and increased soil population

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**Betti et al., 2003 [45]**

**Tobacco**

Effect of *As2O3* on tobacco plants inoculated tobacco mosaic virus

Hypersensitivity lesions

*As2O3* 5x, 45x, 5cH and 45cH

Water; potentized water

10 disks of the 3rd or 4th inoculated leaf from each plant were placed in Petri dishes with 15 ml of treatments

Decimal HD, 45x in particular, reduced** the number of hypersensitivity lesions

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**Sukul et al., 2001 [46]**

**Tomato**

Effect of *Cina maritima* in HD on *Meloidogyne incognita*

Root gall number and nematode population

*Cina* 200c and 1000c

Globules impregnated with 90% hydroalcoholic solution

Leave spraying of 10 ml/plant of treatments (7.2 mg globules/ml distilled water), once per day, 10 days

*Cina* 200c reduced** gall number/plant; both HD reduced** the root nematode population

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**Sukul & Sukul 1999 [47]**

**Cowpea**

Effect of *Cina maritima* on *Meloidogyne incognita*

Gall number; nematode population

*Cina* 1000c

Globules impregnated with 90% hydroalcoholic solution

Leave spraying

Reduction of gall number and root and soil nematode population

**Table 3. Main studies on the effect of homeopathic high dilutions on plants subjected to abiotic stress**

<table>
<thead>
<tr>
<th>Author, year</th>
<th>Species</th>
<th>Aims</th>
<th>Parameters</th>
<th>Treatment</th>
<th>Controls</th>
<th>Frequency and mode of application</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brizzi et al., 2011 [48]</td>
<td>Wheat</td>
<td>Effect of <em>Arsenicum album</em> 45x on germination of seeds previously exposed to <em>As2O3</em></td>
<td>Germination rate</td>
<td><em>Arsenicum album</em> 45x</td>
<td>Distilled water; distilled water 45x</td>
<td>Seeds were exposed to <em>As2O3</em> 30 min and rinsed (60 min) with water before treatments, heated 30 min at 20, 40, 70 and 100ºC (5 min)</td>
<td><em>Arsenicum 45x enhanced</em>* seed germination; efficacy was not changed by heating up to 40ºC, but decreased at 100ºC</td>
</tr>
<tr>
<td>Authors</td>
<td>Species</td>
<td>Effect of 3 substances in HD on plant growth after exposure to As$_2$O$_3$</td>
<td>Number and foliar area; leave color</td>
<td>Water; succussed water</td>
<td>Exposure to As$_2$O$_3$ 48 h (intoxication), then plants were transferred to other containers with the treatments</td>
<td>Arsenicum album and nosode increased** the growth rate of plants</td>
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<tr>
<td>Jager et al., 2011</td>
<td>Lemna gibba</td>
<td>11 substances in HD on plant growth following exposure to As$_2$O$_3$</td>
<td>Arsenicum album, nosode, gibberellic acid, arsenic and other substances in various dilutions</td>
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</table>

**Statistically significant difference**
Discussion

Recent reviews on the effect of homeopathic HD on plants [11-13] performed until 2011 analyzed 167 experimental studies described in 157 articles. These reviews were performed by a same group of authors, who applied a specific scale (MIS) to assess the methodological quality of studies. Scores (0 to 2) were attributed to 5 items: experiment design; materials; measurement instruments; potentization techniques; and type of controls.

Relative to the 167 analyzed experimental studies, global assessment [16] showed that 84 (50%) included statistical analysis and 48 (29%) attained the minimum score required (MIS $\geq 5$) for adequate interpretation of results. 29 studies (17%) used adequate controls to detect specific effects of homeopathic HD; these studies found significant effects with HD over Avogadro’s number. 10 studies (6%) systematically used negative controls (placebo group).

Among 48 experimental studies with MIS $\geq 5$, wheat was the species most often used (23 studies), followed by dwarf pea and gibbous duckweed (3 studies each). Homeopathic agents most frequently used were: silver nitrate (9 studies), arsenic (8 studies), gibberellic acid (6 studies) and Cina maritima (4 studies). Various HD were tested; linear relationship was not found between HD level and effect size. Some studies applied a broad range of HDs to one same experimental model; the results showed that some HDs were active, while others were not. In healthy plants, some HD enhanced germination, while others inhibited it, which evidences the biphasic effect of the various concentrations [16,36].

Analysis of the reviews [16] showed that among 86 studies conducted with healthy plants [11] 43 (50%) included statistical analysis; 29 (34%) had MIS $\geq 5$; 15 (17%) used adequate controls; and 5 (6%) systematically employed negative controls [28,30,32,33]. Among 44 studies that tested phytopathological models [12] 19 (43%) included statistical analysis; 6 (7%) had MIS $\geq 5$; 6 (7%) used adequate controls; and 1 (2%) systematically employed negative controls [42]. Among 37 studies with plants exposed to abiotic stress [13], 22 (68%) included statistical analysis; 13 (35%) had MIS $\geq 5$; 8 (22%) used adequate controls; and 4 (11%) systematic use of negative controls [48,50-52].

To assess the reproducibility of homeopathic experiments in plants, which might confirm the validity of isolated results, recent reviews [14,15] clustered studies per line of research. Among the models with healthy plants, experiments belonging to lines of research ‘wheat seedlings & silver nitrate’ [9,38,40,56,57], ‘dwarf pea and gibberellic acid’ [30,33], ‘wheat seedlings/stalk growth & gibberellic acid [21-23,25,26] and ‘wheat seedlings/germination & gibberellic acid’ [24,58] stand out. Among the models with plants exposed to abiotic stress and following treatment, experiments of ‘intoxication of wheat seedlings with arsenic & Arsenicum album’ [48,53-55,59] predominated.

In the first review of studies of HD on plants, in 1984, Scofield [10] called the attention to methodological flaws in study design and development among the analyzed experiments, including: inadequate sample size; no statistical analysis; no detailed description of methods (selection and preparation of medicines, dose, mode of application, etc.) or controls; no double-blinding; inadequate control and reproducibility of experiments; and inadequate outcome measures, among others.
In addition to the aforementioned flaws, easily corrected through rigorous observance of the assumptions of the scientific method, aspects intrinsic to homeopathy make systematization and improvement of experiments difficult, such as the complexity inherent to selection of individualized medicines and application of HD. However, analysis of the studies published in the past decades evidenced a qualitative leap in the research conducted with homeopathic HD in plants, including suggestions for improvement of the design, development and description of this type of experiments [17,60-64].

Although systematic use of negative controls and reproducibility ought to be routine components of future studies with homeopathic HD on plants to ensure the system stability, exclude false-positive results and confirm the validity of results, some aspects might hinder their internal or external reproducibility, such as: relevant parameters that cannot be controlled; inadequate outcome measures; and inherent irreproducibility. Many false-positive results might be related to artifact, be the result of contamination, systematic deviation or random noise of the experimental design, while they are mistakenly interpreted as effects of treatment [14,15].

According to Baumgartner [17,60,65] the reproducibility of homeopathic experiments is a complex issue, as a function of the many factors involved, for which reason interactive approaches are needed.

As mentioned above, we need to stress once again the need for researchers to congregate around the production of a homeopathic materia medica specific for plants, a project launched in Brazil in 2003 [5-8,20,66,67]. The availability of such materia medica is an indispensable requirement for the selection of individualized medicines for treatment of the various plant disorders and diseases. This need recently reasserted by other authors [13,16,22], such materia medica would allow for the application of the classic therapeutic similitude principle based on the similarity between the signs and symptoms elicited by homeopathic medicines during homeopathic pathogenetic trials on plants and the signs and symptoms exhibited by the plant species to be treated. Except for isotherapy – which employs HD of pathogens to prevent and/or treat the harmful effects they themselves cause (analogously to immunization and immunotherapy in humans, respectively), the vast majority of medicines used for homeopathic treatment of plants is empirically and unspecifically selected (without description of the method of selection used), but analogically from the signs and symptoms described in the traditionally materia medica (result of pathogenetic trials of substances on human beings).

As a complementary suggestion and reproducing our work with modern drugs in the past decade (with the goal to use them based on the similarity between the adverse effects they induce and the signs and symptoms of patients, see New homeopathic medicines: use of modern drugs according to the similitude principle, www.newhomeopathicmedicines.com) [68-73] a homeopathic materia medica for plants might begin by the survey, systematization and organization of the signs and symptoms elicited in plants by the various substances commonly used in agricultural practice (mineral, pesticides, fertilizers, etc.) to be later complemented with classical homeopathic pathogenetic trials.

To illustrate the validity of this method, the study by Betti et al. [45] employed arsenic trioxide \((\text{As}_2\text{O}_3)\) to reduce the severity of infection with the tobacco mosaic virus (TMV). The medicine was selected based on the classical therapeutic similitude
principle, i.e., similarity of signs and symptoms, once the authors observed that application of As$_2$O$_3$ in toxic dose to tobacco leaves caused lesions similar to the ones of TMV-induced hypersensitivity. The results showed that homeopathic treatment with As$_2$O$_3$ in HD significantly increased the plant resistance to TMV, assessed based on the number of hypersensitivity lesions.

Betti’s group also succeeded in reducing the symptoms caused by fungus Alternaria brassicicola to cauliflower with As$_2$O$_3$ 35x. This medicine was selected based on a pathogenetic trial of 1mM As$_2$O$_3$ on cauliflower, which resulted in symptoms similar to the ones induced by the fungus [74].

Similar studies conducted in Brazil detected similarity between the pathogenetic signs and symptoms of eucalyptus oil on bean plants and the ones caused by fungus Pseudocercospora griseola, namely, the etiologic agent of angular leaf spot [66,75]. Studies on reduction of infection of bean plants with P. griseola are still incipient, but point to possible control of angular leaf spot with potentized eucalyptus oil [76] via activation of biochemical mechanisms of plant defense [77].

**Conclusions**

Effect of homeopathic HD on plants was demonstrated in various experimental models with satisfactory methodological quality. These studies systematically employed negative controls and exhibited reproducibility, with consequent reduction of the odds of false-positive results; thus the validity of the results is confirmed.

In addition to the confirmation of the effect of HD on various biological systems, the positive results of homeopathic experiments with plants lend support to the plausibility of homeopathic treatment for human diseases, as factors doctor-patient relationship and placebo effect – commonly mentioned by skeptics to account for the improvement observed in homeopathic clinical practice – are absent.

The methodological flaws of the older studies notwithstanding, the advances in homeopathic research on plants made in the past decades – as a function of the advantages proper to this experimental model and of an increasing interest in the use of homeopathy in agroecology - point to a promising field of research to elucidate the particularities of the mechanism of action of homeopathic HD and to broaden the scope of their therapeutic use.

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