Homeopathy (2009) 98, 244–266

doi:10.1016/j.homp.2009.09.008, available online at http://www.sciencedirect.com

ORIGINAL PAPER

Use of homeopathic preparations in phytopathological models and in field trials: a critical review

Lucietta Betti[1,*], Grazia Trebbi[1], Vera Majewsky[2,3], Claudia Scherr[4], Devika Shah-Rossi[4], Tim Jäger[2,3] and Stephan Baumgartner[2,4]

[1]*Department of Agri-Environmental Sciences and Technologies, University of Bologna, Italy*
[2]*Institute of Complementary Medicine KIKOM, University of Bern, Switzerland*
[3]*Research Institute of Organic Agriculture FiBL, Frick, Switzerland*
[4]*Hiscia Institute, Society for Cancer Research, Arlesheim, Switzerland*

Background: **The literature on the applications of homeopathy for controlling plant diseases in both plant pathological models and field trials was first reviewed by Scofield in 1984. No other review on homeopathy in plant pathology has been published since, though much new research has subsequently been carried out using more advanced methods.**
Objectives: **To conduct an up-to-date review of the existing literature on basic research in homeopathy using phytopathological models and experiments in the field.**
Methods: **A literature search was carried out on publications from 1969 to 2009, for papers that reported experiments on homeopathy using phytopathological models (*in vitro* and *in planta*) and field trials. The selected papers were summarized and analysed on the basis of a Manuscript Information Score (MIS) to identify those that provided sufficient information for proper interpretation (MIS $\geq$ 5). These were then evaluated using a Study Methods Evaluation Procedure (SMEP).**
Results: **A total of 44 publications on phytopathological models were identified: 19 papers with statistics, 6 studies with MIS $\geq$ 5. Publications on field were 9, 6 with MIS $\geq$ 5. In general, significant and reproducible effects with decimal and centesimal potencies were found, including dilution levels beyond the Avogadro's number.**
Conclusions: **The prospects for homeopathic treatments in agriculture are promising, but much more experimentation is needed, especially at a field level, and on potentisation techniques, effective potency levels and conditions for reproducibility. Phytopathological models may also develop into useful tools to answer pharmaceutical questions.**
Homeopathy (2009) **98**, 244–266.

Keywords: Homeopathy; Agriculture; Phytopathological models; Plant disease control; Field trials

Introduction

In developed countries modern, intensive agriculture has improved crop yields but also, due to its reliance on large amounts of non-renewable energy and raw materials, frequently resulted in soil degradation, environmental pollution and damage to wildlife. For this reason, in recent years there has been growing interest in agricultural methods that are

*Correspondence: Lucietta Betti, Department of Agro-Environmental Sciences and Technologies, University of Bologna, Viale Fanin 42, 40127 Bologna, Italy.
E-mail: lucietta.betti@unibo.it
Received 1 July 2009; revised 17 September 2009; accepted 23 September 2009

both environmentally and economically sound. Among these, the emerging discipline of 'agrohomeopathy' – the application of homeopathy to agriculture – is currently being widely developed.[1] The potential benefits are significant because homeopathic preparations, due to their ultra high dilution, are relatively cheap, have few or no ecological side-effects and seem to be, on the whole, harmless.[2,3] All these attributes make homeopathy optimally suited to the holistic approaches of organic and, above all, biodynamic agriculture, in which plants and their interactions with the environment are treated as a unified 'living organism'.[4–8] What is more, this novel approach of applying homeopathic principles to agriculture can also be aimed at improving the nutritional properties (i.e. the level of compounds inducing physiological benefits to human health)[9] and physiological and qualitative characteristics of plants, in addition to their resistance to biotic (insects and pathogens) and abiotic (physical and chemical damage) stress. Infected plants, being out of equilibrium, with the innate tendency to return to the equilibrium state known as health[10] may also be useful experimental systems to identify specific effects of homeopathic preparations.

This review discusses the experimental evidence relating to the use of homeopathic preparations in plant pathology, in particular, in both phytopathological models (*in vitro* and *in planta* experiments) and field trials (healthy/diseased crop experiments), with a view to assessing the potential of agrohomeopathy. The previous review by Scofield[11] did not use predefined criteria to assess the quality of studies. This paper aims to describe and evaluate the current state of research.

Methods

Data sources

References were collected from Medline®, from the Basic Research Database of the Karl and Veronica Carstens-Foundation, Essen, Germany,[12,13] the private library of Baumgartner (KIKOM, Bern University) and from the library of the Department of Agri-Environmental Science and Technology (Bologna University). All the reviews and publications obtained from these sources were screened for further references. In some cases we also made direct contact with the authors.

Literature review

This review covers papers reporting experiments based on phytopathological models (plants naturally infected or artificially inoculated with fungi, viruses, bacteria, nematodes), *in vitro* spore germination and growth models, and field trials (agronomical and phytopathological experimentations). All languages were included, and all the papers were analysed using the reviewing procedure described by Majewsky,[14] which comprises statistics, a Manuscript Information Score (MIS) and a Study Methods Evaluation Procedure (SMEP). A brief description is given of each paper. Substances known as homeopathic remedies are listed using common abbreviations, and the taxonomy of fungi has been updated according to http://www.indexfungorum.org. All the papers were independently evaluated by two reviewers, with any differences resolved through discussion.

Results

Phytopathological and *in vitro* models

A total of 44 publications were found in the literature search,[10,15–57] comprising 24 plant/fungus studies, 11 plant/virus studies, 6 plant/nematode studies and 3 studies on plant/bacteria interactions. The earliest paper dated from 1969,[39] while the most recent was published in 2009.[10] 25 were excluded because they did not use statistical analysis to evaluate the results, or did not mention the statistics in the paper.[18,20,26–35,38] The remaining 19 papers (published from 1976 to 2009) were put through the reviewing procedure[10,15–17,19,21–25,36,37,47–49,54–57]: 6 of the 19 publications achieved a MIS of 5 points or more.[10,49,54–57] The papers were then evaluated for their SMEP (see Methods section[14]), which takes into account the use of controls, blinding, randomisation, and the number of independent experiments and systematic negative control experiments as key methodological factors.[58] The main experimental data of the publications with MIS < 5 are reported in Table 1 (plant/fungus interactions) and Table 2 (plant/virus, bacteria, nematode interactions); papers with MIS ≥ 5 are described in Table 3.

Plant/fungus models

Most of the studies were conducted by Indian researchers and focused on *in vitro* fungal spore germination and colony growth, and on *in vivo* fungal disease control following homeopathic treatments (Table 1). Khanna and Chandra[15–17] investigated the effectiveness of homeopathic treatments in controlling fruit rot caused by the following fungi: *Gibberella zeae* (Schwein.) Petch (Syn. = *Fusarium roseum* Link), *Pestalotiopsis psidii* (Pat.) Mordue (Syn. = *Pestalotia psidii* Pat.) and *Pestalotiopsis mangiferae* (Henn.) Steyaert (Syn. = *Pestalotia mangiferae* Henn.). After initially screening a number of homeopathic treatments (normally used for fungal diseases in humans) in centesimal potencies (1–200), to determine their effect on fungal spore germination, those potencies which induced complete inhibition were tested *in vivo* on infected fruits, either before or after fungus inoculation. The statistical analyses show some significant positive results, especially with pre-inoculation treatments. The same authors[18,19] also studied the effects of some homeopathic treatments on spore germination of *Alternaria alternata* (Fr.) Keissl. (a fungus that causes leaf blight of wheat) isolated from citrus (*Citrus microcarpa* (Bunge) Wijnands), flax (*Linum usitatissimum* L.), guava (*Psidium friedrichsthelianum* (O. Berg) Niedenzu) and wheat (*Triticum aestivum* L.). The potencies found to have the strongest inhibiting effect were then tested *in vivo* by spraying wheat plants prior to fungus inoculation[19]: only two of the tested potencies reduced disease intensity (41% and 56% reduction with *Arsenicum album* 199c and *Kalium iodatum* 200c, respectively). Kehri and Chandra[20] reported the results of an *in vitro* and *in vivo* evaluation of some homeopathic treatments against *Lasiodiplodia*

Table 1 Main experimental items of papers on plant/fungus interaction (all with MIS < 5)

Publication [reference number]	*Host/Pathogen*	*Measured parameters*	*Number n (per treatment and experiment)*	*Test substance*/ potency levels*	*Potentisation*	*Control*	*Statistical analysis†*	*Findings‡*
Aggarwal *et al.*[36]	Taro/*Phytophtora colocasiae*	a) Mycelial growth b) Sporangial production c) Pectolytic, cellulolytic enzyme production d) *In vivo* disease control	a) Not reported b, c, d) 5	Kali-i, Ars a, Thuj, Blatta 3, 30, 200c	Ref§	Not reported	M, SE, PDI; ANOVA, Duncan's multiple range test	a) Inhibition** by all the treatments b) Inhibition by Kali-i, Ars a 30, 200c c) Inhibition by all the treatments, especially Kali-i 200c d) Disease** control by Kali-i, Ars a 200c
Chaube *et al.*[28]	*Cochliobolus miyabeanus*, *Haematonectria haematococca*, *Penicillium decumbens*	% spore inhibition	3	Apis, Ars a, Bell, Blatta, Bry, Euph, Lyc, Kali-i, Nux-v, Pho, Sulph, Sep, Thuj 30, 200c	Not reported	Not reported	Data in %; tests not reported	Inhibition by Apis, Kal-i, Thuj, Sulph; stimulation by Bry, Euph 30, 200c
Dua *et al.*[34]	*Alternaria solani, Lasiodiplodia theobromae*	Dry mycelial weight	Not reported	Ars a, Blatta, Cina, Lyc, Thuj 1, 4, 7, 13, 31, 201c	Ref‖	Distilled water	Data in % *vs.* control; tests not reported	Inhibition more than 50%: for *A. solani* by all treatments; for *B. thoebromae* by Ars a 31, 201c, Blatta 7, 13, 31c; Thuj 1, 7, 13, 31, 201c
Kehri and Chandra[20]	Guava/ *Lasiodiplodia theobromae*	a) *In vitro*: % spore germination b) *In vivo*: % fruit rot	a) 3 b) 3 of 10 fruits	Ars a, Kali-i, Blatta 7, 31, 201, 1001c	Ref¶	Sterilized distilled water	Data % *vs.* control; tests not reported	a) Total inhibition by Ars a; increase by Kali-i, Blatta b) Strong fruit rot reduction by Ars a
Khanna[27]	Wheat/*Fusarium oxysporum*	a) External and internal seed-borne mycoflora b) Spermosphere mycoflora c) Spermoplane mycoflora	4 of 100 seeds or 100 seedlings	Lyc, Thuj 3, 6x, 30, 200c	Ref¶	Absolute ethyl alcohol in sterilized distilled water (1:100)	Data in %; tests not reported	a) Suppression by Lyc 3x, Thuj 30, 200c; reduction by Lyc 6x b) Suppression by Lyc 30, 200c, Thuj 3, 6x and 30, 200c; reduction by Lyc 6x c) Suppression by Lyc 30c, Thuj 3, 6x and 30, 200c
Khanna and Chandra[18]	*Alternaria alternata*	*In vitro* spore germination	Not reported	Ars a, Blatta, Kali-i, Thuj 1-200c	Ref#	Not reported Not reported	Not reported	Total inhibition, in citrus isolate, by Ars a 28, 38, 146c, Blatta 106, 137, 191c, Kali-i 90, 105, 164, 199c, Thuj 46c; in flax isolate, by Ars a 26, 150, 155, 199c, Blatta 21, 200c, Kali-i 34, 155, 77, 199c; in guava isolate, by Ars a 35, 82, 96, 101c, Blatta106, 137, 191c, Kali-i 90, 105, 164, 199c, Thuj 46c; in wheat isolate, by Ars a 82, 90, 96, 143, 199c, Kali-i 129, 149, 200c, Thuj 152c

Khanna and Chandra[15]	Tomato/ *Gibberella zeae*	a) *In vitro*: % spore germination b) *In vitro* pathogen growth c) *In vivo*: % fruit infected and rot developed	a) 3 b) Not reported c) 5 of 12 fruits	Ars a, Blatta, Kali-i, Lyc, Thuj, Pho, Asv 1-200c	Ref[#]	Not reported	Data in % and % *vs.* control; C.D. at $p \leq 0.05$; tests not specified	a) Total inhibition by Ars a 1c, Kali-i 149c, Pho 35c, Thuj 87c b) Total inhibition by Kali-i 149c, Thuj 87c c) Inhibition by Kali-i 149c, Thuj 87c
Khanna and Chandra[16]	Guava/ *Pestalotiopsis psidii*	a) *In vitro*: % spore germination b) *In vitro*: pathogen growth c) *In vivo*: % rot developed	a) 3 b) Not reported c) 5 of 12 fruits	Ars a, Blatta, Kali-i, Thuj 1-200c	Ref[#]	Sterilized distilled water	Duncan's multiple range test	a) Total inhibition by Ars a 60, 65, 181c, Kali-i 1, 20, 24, 61, 87c b) Inhibition by Ars a 60c, Kali-i 1, 20, 24, 61c c) Inhibition by Ars a 60, 65, 181c, Kali-i 1, 20, 24, 61, 87c
Khanna and Chandra[19]	Wheat/*Alternaria alternata*	a) *In vitro*: % spore germination b) *In vivo*: % disease index on leaves	a) 3 b) 5	Ars a, Blatta, Kali-i, Thuj 1-200c	Ref[#]	Not reported	PDI, SE, C.D. at $p \leq 0.05$; tests not specified	a) Total inhibition by Kali-i 129, 149, 200c, Ars a 82, 90, 96, 143, 199c, Thuj 152c b) Reduction by Kali-i 200c, Ars a 199c
Khanna and Chandra[17]	Mango/ *Pestalotiopsis mangiferae*	a) *In vitro*: % spore germination b) *In vivo*: % fruit infected and rot developed	a) 3 b) 5 of 12 fruits	Ars a, Blatta, Kali-i, Lyc, Thuj, Pho, Asv, Zin-s, Fil-m, Kali-m 1-200c	Ref[16]	Sterilized distilled water	ANOVA; Duncan's multiple range test; C.D. at $p \leq 0.05$	a) Total inhibition by Ars a 1, 89, 90c, Pho 50c, Asv 100c, Lyc 190c, Zinc-s 1, 2c b) Inhibition by Lyc 190c
Khanna and Chandra[17]	*Alternaria alternata*, *Colletotrichum coccodes*, *Gibberella zeae*, *Glomerella cingulata*, *Pestalotiopsis mangiferae*, *Pestalotiopsis psidii*	a) % spore germination b) Mycelial growth and sporulation	3	Ars a, Asv, Blatta, Fil-m, Kali-i, Kali-m, Lyc, Pho, Thuj, Zin-s 1-30x, 1-200c	Ref[¶,16]	Sterilized distilled water	C.D. at $p \leq 0.05$; r, *t*-test,	a) General inhibition, with different ranges of action b) General inhibition
Khanna and Chandra[22]	Tomato/ *Gibberella zeae*; Mango/ *Pestalotiopsis mangiferae*; Guava/ *Pestalotiopsis psidii*	a) % infected fruit, fruit rot b) Amino acids, amides, sugars a, organic acids, vitamin C c) Organoleptic tests d) Cost/benefit ratio	3	Kali-i 149, 87c; Lyc 190c. Adjuvants: glycerol, castor oil, paraffin oil, soap powder, wheat flour	Ref[16]	The same treatments without adjuvants	ANOVA, Duncan's multiple range test at $p \leq 0.05$	a) Reduction[**] with soap powder b) n.s. between untreated and treated fruits c) No changes in taste, palatability d) Treatments result economical

(*continued on next page*)

Table 1 (*continued*)

Publication [reference number]	*Host/Pathogen*	*Measured parameters*	*Number n (per treatment and experiment)*	*Test substance*/ potency levels*	*Potentisation*	*Control*	*Statistical analysis†*	*Findings‡*
Khanna and Chandra[25]	Guava/ *Lasiodiplodia theobromae*, *Geotrichum candidum*	a) *In vitro*: % inhibition of pathogen growth b) *In vivo*: % infected fruits and rotting development	a) Not reported b) 3 of 10 fruits	Bry, Fil-m, Fuc, Kali-i, Kali-bi, Lyc, Nux-v, Pho, Spong, Stict, Thuj, Zin-s 3, 6x, 30, 200c	Ref[¶]	a) Absolute ethyl alcohol b) Sterilized distilled water	Data in %, SE; C.D. at $p \leq 0.05$	a) *L. theobromae* inhibition by Kali-i, Pho 3x, Kali-bi 200c, Thuj 6x; *G. candidum* inhibition by Fil-m 6x, 30c, Kali-bi, Nux-v 3x, 30c, Lyc 30c; Spong 6x; Thuj 3x b) *L. theobromae* rot reduction by Kali-bi 200c, Kali-i, Pho 3x; *G. candidum* rot reduction by Kali-bi, Lyc 30c
Khanna and Chandra[23]	*Alternaria alternata*, *Colletotrichum coccodes*, *Gibberella zeae*, *Glomerella cingulata*, *Pestalotiopsis mangiferae*, *Pestalotiopsis psidii*	a) Respiration rate of germinating spores b) Organic acid pool	Not reported	Ars a 3x, 1, 60, 65, 90, 96, 181c; Asv 100, 140, 200c; Blatta 148c; Fil-m 40, 130, 180, 184, 192c; Kali-i 12x, 1, 20, 24, 50, 61, 87, 149c; Kali-m 3, 12, 14x, 47, 52c; Lyc 27, 39, 50, 136, 142, 186, 190, 193, 199c; Pho 18x, 35, 50c; Thuj 87c; Zin-s 2, 3, 4x, 2, 30, 47c	Ref[16]	Distilled water	C.D. at $p \leq 0.05$; r, *t*-test	a) Decrease** by most of the treatments b) Changes depending on treatment
Khanna and Chandra[24]	Apple, Tomato/ *Alternaria alternata*; Banana/ *Gibberella zeae*; Mango/ *Glomerella cingulata*; Guava/ *Colletotrichum coccodes*	a) % of fruit infected and fruit rot b) Adjuvant effect c) Amino acids, amides, sugars a, organic acids, vitamin C levels d) Organoleptic tests e) Cost/benefit ratio	5 of 12 fruits	Ars a 3x, 1c; Asv 200c; Blatta 148c; Fil-m 180, 184, 192c; Kali-i 12x, 149c; Kali-m 3, 14x, 47, 52c; Lyc 39, 50, 136, 142, 199c; Zin-s 3, 4x, 2, 30, 47c Adjuvants: glycerol, castor oil, paraffin oil, soap powder, wheat flour	Ref[22]	Not reported	C.D. at $p \leq 0.05$	a) Reduction** by Asv 200c in apple, tomato; by Kali-i 149c in banana; by Lyc 136c in guava; by Lyc 142c in mango b) Efficacy enhancement with soap c) n.s d) No changes in taste, palatability e) Treatments result economical
Khanna *et al.*[26]	Wheat seeds/ *Fusarium oxysporum*, *Alternaria alternata*, other seed-borne fungi	a) % occurrence of external and internal mycoflora b) Seed germination	5 of 100 seeds	Fil-m, Blatta 3, 6, 30, 200x	Ref[¶]	Absolute ethyl alcohol in sterilized distilled water (1:100)	Data in %; tests not reported	a) *F. oxysporum* complete suppression by 30, 200x of both treatments; *A. alternata* reduction by Blatta b) Any substantial variation

Kumar and Kumar[29]	*Alternaria alternata*, *Pseudocochliobolus pallescens*, *Cochliobolus australiensis*	a) *In vitro*: % spore germination b) *In vitro* fungal colony diameter	3	Cina, Spig, Stann, Sulph, Teu 30, 200c	Not reported	Absolute alcohol	M; test not reported	a) Inhibition by Spig 30c, Sulph 30, 200c, Teu 200c in all test fungi b) *A. alternata* stimulation by all the treatments; in *D. australiensis* inhibition by all the treatments
Mishra[31]	Coriander, cumin/ *Aspergillus niger*	a) *In vitro*: % spore germination b) *In vitro*: fungal growth c) *In vivo*: % seed deterioration	a) 3 b) Not reported c) Not reported	Ars a, Ant-c, Calc-c, Clem, Graph, Pho, Sars a, Sulph, Sil 30, 200c	Not reported	Double distilled and sterilized water	Data in %; tests not reported	a), b) Inhibition by Ars a, Calc-c, Graph, Pho 200c c) Almost 100% reduction by Calc-c 200c; up to 50% reduction by Ars a, Graph, Pho 200c
Misra *et al.*[30]	*Aspergillus parasiticus*	a) *In vitro*: dry weight b) Aflatoxin production	a) 3 b) Not reported	Apis, Arn, Ars a, Bell, Blatta, Bry, Carb, Cina, Euph, Lyc, Nux-v, Pul, Sep, Thuj 200c	Not reported	Not reported	Data in % *vs.* control; test not reported	a) Inhibition more than 50% by Blatta, Bry, Sep b) Inhibition more than 50% by Arn, Bell, Bry, Carb, Cina, Pul, Sep, Thuj; stimulation by Blatta, Euph
Rivas *et al.*[37]	Tomato, Wheat/ *Alternaria solani*, *Alternaria alternata*	a) *In vitro*: fungal spore germination b) % contaminated and germinated seeds c) Seedling growth	a) 4 (3 indipendent experiments) b) Not reported	Ars a, Calc-c, Cupr, Ferr, Lyc, Nat-m, Pho, Sel, Sil, Sulph 31-33, 201-203c	c scale, dilutions in distilled water	Dynamized water (a); distilled water (b, c)	a) Duncan test at $p \leq 0.05$ b), c) not reported	a) Total inhibition by Sel 31c; decrease** by Cupr 201, 203c, Nat 202c, Sulph 202c b) n.s. in tomato seeds and seedlings; increase of contaminated wheat seeds by Lyc 201c, Nat 202c, Sulph 201c and decrease by Cupr 203c c) Increase by Cupr 202, 203c, Sulph 202c
Rolim *et al.*[38]	Apple/ *Podosphaera leucotricha*	Disease incidence	4 of 1 plant	Kali-i, Lach, Staph 30, 100c; Sulph 30c; Oid 100c	Not reported	Not reported	Tests not specified	Reduction** by Staph 100c
Saxena *et al.*[35]	Reed okra/seed-borne fungi	a) % occurrence of seed-borne fungi b) % seed germination and root-shoot length	5 of 10 seeds	Thuj LM, 30, 200c; Sulph LM, 30, 200c; Teu LM; Nit-ac, Calc-c 30, 200c	Not reported	Absolute alcohol	Data in % *vs.* control; tests not specified	a) Total inhibition by Thuj, Nit-ac, Sulph 200c; Nit-ac 30c, Teu LM failed to control some fungi b) Increase** by all the treatments

(*continued on next page*)

Table 1 (*continued*)

Publication [reference number]	*Host/Pathogen*	*Measured parameters*	*Number n (per treatment and experiment)*	*Test substance*/ potency levels*	*Potentisation*	*Control*	*Statistical analysis*[†]	*Findings*[‡]
Singh[33]	*Nannizia incurvata*, *Malbranchea aurantiaca*, *Botryotrichum keratinophilum*	a) *In vitro*: fungal colony diameter b) *In vitro*: dry mycelial weight	2	Bac, Sep 30, 200, 1000c; Fag, Petr 6, 200, 1000c	c scale in sterile double distilled water	Petri dishes without any treatments	Data in % *vs.* control; tests not reported	a) Inhibition more than 50%, in *N. incurvata*, by Bac 1000c, Fag 6, 200, 1000c, Petr 1000c, Sep 1000c; in *M. aurantiaca* by Bac, Sep 30, 200, 1000c, Fag, Petr 1000c; in *B. keratinophilum* by Bac 1000c, Fag 200, 1000c, Sep 1000c b) Inhibition more than 80% by 1000c of all the treatments
Singh *et al.*[32]	*Alternaria alternata*, *Cochliobolus lunatus*	*In vitro*: fungal colony diameter	2	Bac, Lyc 30, 200, 1000c; Fag, Ust, Petr, Mez 6, 200, 1000c; Tell, Sep 30, 200, 1000c; Sulph 1000c; Sulph-i 6, 30, 1000c	c scale in double distilled water	Petri dishes without any treatments	Data in % *vs.* control; tests not reported	*A. alternata*: 100% inhibition by all potencies of Bac, Petr, Sep; Lyc 200c; Fag 200, 1000c; Ust 1000c; Sulph-i 1000c; Mez 1000c; *C. lunatus*: 100% inhibition by Fago 200c; Ust 6c; Petr 200c, Sulph-i 6, 1000c

* Test substance: *Ant-c = Antimonium crudum; Apis = Apis mellifera; Arn = Arnica montana; Ars a = Arsenicum album; Asv = Asvagandh; Bac = Bacillinum; Bell = Belladonna; Blatta = Blatta orientalis; Bry = Bryonia; Calc-c = Calcarea carbonica; Carb = Carbokas; Clem = Clematis; Cupr = Cuprum metallicum; Euph = Euphorbium; Graph = Graphites; Fag = Fagopyrum; Ferr = Ferrum metallicum; Fil-m = Filix mas; Fuc = Fucus vesiculosus; Kali-bi = Kali bichromicum; Kali-i = Kali iodatum; Kali-m = Kali muriaticum; Lach = Lachesis; Lyc = Lycopodium; Mez = Mezerium; Nat-m = Natrum muriaticum; Nit-ac = Nitric acid; Nux-v = Nux vomica; Oid = Oidium lycopersici; Petr = Petroleum; Pho = Phosphorus; Pul = Pulsatilla; Sars = Sarsaparilla; Sel = Selenium; Sep = Sepia; Sil = Silicea; Spig = Spigelia; Spong = Spongia tosta; Stann = Stannum; Staph = Staphysagria; Stict = Sticta pulmunaria; Sulph = Sulphur; Sulph-i = Sulphur iodatum; Tell = Tellurium; Teu = Teucrium; Thuj = Thuja; Ust = Ustilago; Zin-s = Zincum sulphuricum*.

† Statistical analysis: M = mean; SE = standard error; PDI = percentage disease index; C.D. = critical difference; r = coefficient of correlation.

‡ Findings: n.s. = no significant differences.

** Significant difference.

§ Bhattacharya *et al.* The homeopathic family practice, 2nd edn, Calcutta: Economic Press 1931.

‖ Bhattacharyya *et al.* Homeopathic Pharmacopoeia, Calcutta, India 1980.

¶ Anonymous. Homoeopathic Pharmacopoeia, Calcutta: M. Bhattacharyya & Co's, Netaji Subbas Road 1970.

Bhattacharyya *et al.* Homeopathic Pharmacopoeia, Calcutta: M. B. and Company Private Ldt. 1970.

Table 2 Main experimental items of papers on plant/virus, bacteria, nematode interactions (all with MIS < 5)

Publication [reference number]	*Host/pathogen**	*Measured parameters*	*Number n (per treatment and experiement)*	*Test substance†/ potency levels*	*Potentisation*	*Control*	*Statistical analysis‡*	*Findings§*
Abidi *et al.*[45]	Papaya/PRSV	a) Fruit infection b) Symptom appearance (in days)	2	Chim, Carbo-v, Lach, Rhus-t, Variolinum 200c	Ref. to[39]	4% alcohol	Data in %; tests not reported	a) Pre-inoculation treatment: decrease by all treatments, especially by Chim; post-inoculation treatment: reduction by Rhus-t b) Pre-inoculation treatment: a marked delay by all treatment, especially by Chim; post-inoculation treatment: no effects
Cheema *et al.*[47]	Papaya/PapMV	a) Mean disease index b) Chlorophyll content	3 of 10 plants	Carb-v, Cedr, Chel, Chen, Thuj 30x	Ref‖	Not reported	MDI, SE; C.D. at $p \leq 0.05$, tests not specified	a) Decrease** by all the treatments, especially by Thuj and Cedr b) n.s.
Cheema *et al.*[48]	Tomato/TMV	a) % mean disease incidence b) Yield	3	Cedr, Thuj 30x; extracts of *Bougainvillea spectabilis*, *Boerrhavia diffusa*, *Clerodendrum aculeatum* at 10% in water; Bavistin and Resorcinol 0.05%, Malathion 0.1%	Not reported	Water	PDI, SE; C.D. at $p \leq 0.05$, tests not specified	a) Decrease** by all the treatments b) Increase** by all the treatments
Kumar and Sharma[52]	*Meloidogyne incognita*	Larval hatching	3	Cina, Spig, Stann, Suplh, Teu 30, 200c	Not reported	Not reported	Data in % *vs.* control; tests not reported	Inhibition by Cina 30, 200c, Spig 200c; stimulation by Stann, Sulph, Teucrium 30, 200c
Khatri and Singh[42]	Goosefoot, tomato/TMV	Local lesions number	Not reported	Kali-m, Kali-s, Kali-p, Ars a, Cedr, Chim, Variolinum 6, 30x	Not reported	Not reported	Not reported	Decrease by 6, 30x Ars a, Cedr, Chim, Variolinum
Khurana[43]	Papaya, tobacco, goosefoot/ PapMV, PLDMV, PRSV	a) *In vitro*: antiviral activity b) *In vivo*: systemic infection, lesion average number	1	Apis, Bell, Bry, Euphr, Sulph, Thuj 30c	Not reported	Distilled water	M, data in %; tests not reported	a) Inhibition by all the treatments for PLDMV; by Bry, Sulph, Thuj for PapMV; by Euphr, Sulph, Thuj for PRSV b) Infection reduction upon 80% by Thuj, Sulph and 50% by Apis and Bry, in papaya and tobacco; lesion number reduction by all the treatments in *C. amaranticolor*

(*continued on next page*)

Table 2 (*continued*)

Publication [reference number]	*Host/pathogen**	*Measured parameters*	*Number n (per treatment and experiement)*	*Test substance†/ potency levels*	*Potentisation*	*Control*	*Statistical analysis‡*	*Findings§*
Khurana[44]	Tobacco/TMV, tomato/ToMV, cucumber or tobacco/CMV, tobacco or thorn apple/PVX, chilli/ PVY, maize/ SCMV	a) *In vitro*: lesion average number b) % systemic infection	Not available	Thuj, Sulph, Chen, Carbo-v, Apis, Bell, Bry, Ars a LM, 30, 200c	Not available	Not available	Not reported	Inhibition more 50% in tobacco/TMV: a) and b) by 30, 200c Thuj, Sulph, 30c Chen, Carbo-v; in tomato/ ToMV: a) by 30, 200c Sulph, 30c Chen, Carbo-v; in cucumber or tobacco/ CMV: a) by 30c Thuj, Sulph, Carbo-v, 30, 200c Chen; b) by 30, 200c Thuj, Chen, 30c Sulph, Carbo-v; in tobacco or thorn apple/ PVX: a) by 30c Thuj, Sulph, Chen, Carbo-v, Apis; b) by 30, 200c Thu, 30c Apis; in chilli/PVY: a) by 30c Thuj, Sulph, Apis; in maize/SCMV: b) by 30, 200c Thuj, Apis
Moreno and Alvarez[50]	Pineapple/ bacteria	Bacterial contamination incidence	Not reported	Cal, Staph 30c; Ars a 40c; Oscilloc 200c	Not reported	Dynamized distilled water	Not reported	Complete suppression by Oscilloc, Staph, Cal
Ray and Pradhan[53]	*Meloidogyne incognita*	*In vitro* nematode mortality	4	5% dilution of Tri, Coff, Sulph, Hyos, Ip, Cina, Teu, Sen, Nux-v, Thuj, Ars a, Cocc, Bell, Rhus-t, Ant-t	Not reported	Distilled water; 5% dilute alcohol; 1% Furadan	Data in %	100% mortality by Ars a, followed by Thuj, Bell, Ant-t, Rhus-t, Sulph, Cocc
Shukla and Joshi[46]	Sorghum/SCMV	Virus inhibition	10 plants (3 indipendent trials)	Ars a, Crot-t, Dulc, Graph, Rhus-t 30, 200, 1000c	Not reported	Not reported	Data in % *vs.* control; tests not reported	80% inhibition by 1000c Ars a, Rhus-t; 200c Dulc; 60% by Dulc 30c, Graph 1000c; 50% by 200c Graph, Rhus-t
Singh *et al.*[41]	Tobacco/TMV	Number of local lesions	Not reported	Ars a, Tyroidinum, Ur-n 7x; Sulph 101c, Carcinocin 1001c, Morgan 31c, Dol 6c, Influenzinum 201c, Vaccininum 31c	Not reported	Not reported	Data in % *vs.* control; tests not reported	Decrease by Ars a, Dol, Morgan, Thyroidinum, Ur-n
Verma and Awasthi[40]	Tobacco or goosefoot/TMV	Number of local lesions	15 leaves	Calc-f, Calc-p, Calc-s, Ferr-p, Kali-m, Kali-p, Kali-s, Mag-p, Nat-m, Nat-p, Nat-s, Sil 6x	Ref¶	Sterile water	Data in % *vs.* control; tests not reported	In *Nicotiana tabacum* decrease by Calc-f, Calc-p, Ferr-p, Kali-m, Kali-p, Kali-s, Nat-m, Nat-s; in *N. glutinosa* decrease by Calc-p, Calc-s, Kali-p, Kali-s, Nat-p, Nat-s

Verma *et al.*[39]	Tobacco/TMV	a) TMV multiplication rate b) Number of local lesions	Not reported	Al, Chin, Pul, Hydr, Art, Vib, Aco, Bell, Lob, Dig, Ech, Bapt 2c; Ars a 2, 31c; Thuj, Cedr, Ip, Pyr 7c; Chen 7, 32x, 31c; Carbo-v, Variolinum 7x, 31c; Lach 7x, 31, 1001c; Chim 7, 32x, 31, 201, 1001c; Als, Jal 31c	Ref[#]	Not reported	Data in % *vs.* control; tests not reported	a) In *Nicotiana tabacum* and *N. glutinosa* decrease by Carbo-v, Cedr, Chen, Lach, Var 7x, Chim 7x, 31, 1001c; only in *N. glutinosa* by Ars a 2c, Ip 7x; only in *N. tabacum* by Art, Vib, Bell, Dig 2c; Chim 1001c, Als 31c b) In *N. glutinosa* reduction by Ars a, Carbo-v 31c, Chen 32x, Chim 7, 32x, 1001c
Villegas *et al.*[51]	Sugarcane/ *Xanthomonas albilineans*	Bacterial contamination incidence	Not reported	Staph, Oscilloc, Sulph, Cal (5 ml in 1l of in growth medium; potency not reported)	Not reported	Growth medium	Not reported	Complete suppression

* Host/pathogens: PRSV = papaya ringspot virus; PapMV = papaya mosaic virus; TMV = tobacco mosaic virus PLDMV = papaya leaf distortion mosaic virus; ToMV = tomato mosaic virus; CMV = cucumber mosaic virus; PVX = potato virus X; PVY = potato virus Y; SCMV = sugarcane mosaic virus.
† Test substance: *Aco = Aconitum napellus; Al = Aletris; Als = Alstonia constricta; Ant-t = Antimonium tartaricum; Apis = Apis mellifera; Ars a = Arsenicum album; Art = Artemisia vulgaris; Bapt = Baptisia tinctoria; Bell = Belladonna; Bry = Bryonia; Cal = Calendula; Calc-f = Calcarea fluorica; Calc-p = Calcarea phosphorica; Calc-s = Calcarea sulphurica; Carbo-v = Carbo vegetabilis; Cedr = Cedron; Chel = Chelidonium majus; Chen = Chenopodium,; Chim = Chimaphilla; Chin = China; Cocc = Cocculus; Coff = Coffea cruda; Crot-t = Croton tiglium; Dig = Digitalis purpurea; Dol = Dolichos; Dulc = Dulcamara; Ech = Echinacea angustifolia; Euphr = Euphrasia; Graph = Graphites; Ferr-p = Ferrum phosphoricum; Hydr = Hydrastis canadensis; Hyos = Hyoscyamus; Ip = Ipecacuanha; Jal = Jalapa; Kali-m = Kali muriaticum; Kali-p = Kali phosphoricum; Kali-s = Kali-sulphuricum; Lach = Lachesis; Lob = Lobelia inflata; Mag-p = Magnesia phosphorica; Nat-m = Natrum muriaticum; Nat-p = Natrum phosphoricum; Nat-s = Natrum sulphuricum; Nux-v = Nux vomica; Pul = Pulsatilla; Pyr = Pyrogenium; Oscilloc = Oscillococcinum; Rhus-t = Rhus toxicodendron; Sen = Senega; Sil = Silicea; Spig = Spigelia; Stann = Stannum; Staph = Staphysagria; Sulph = Sulphur; Teu = Teucrium; Thuj = Thuja; Tri = Trillium; Ur-n = Uranium nitricum; Vib = Viburnum prunifolium.*
‡ Statistical analysis: M = mean; SE = standard error; MDI = mean disease index; PDI = percentage disease index; C.D. = critical difference.
§ Findings: n.s. = no significant differences.
** Significant difference.
‖ Anonymous. Homoeopathic Pharmacopoeia, Calcutta: M. Bhattacharyya & Co's, Netaji Subbas Road 1970.
¶ Bhattacharyya *et al.* Homeopathic Pharmacopoeia. Calcutta: M. B. and Company Private Ldt. 1970.
# Bhattacharya *et al.* The homeopathic family practice, 2nd edn, Calcutta: Economic Press 1931.

Table 3 Main experimental items of papers on phytopathological models with MIS ≥ 5

Publication [reference number]	*Host/ pathogen**	*Methods†*	*Number n (per treatment and experiment)*	*Number n (independent experiments)*	*Measured parameters*	*Treatment*	*Test substance‡/ potency levels*	*Potentisation*	*Control§*	*Statistical analysis‖*	*Findings¶*
Betti *et al.*[49]	Tobacco/ TMV	b, r	10 Petri dishes with 9 leaf disks for each treatment	3 for 45 dH, 5, 45 cH potencies; 5 for 5 dH potency	a) Hypersensitive lesion number per leaf disk b) Variability evaluation	Immersion of leaf disks	Arsenic trioxide 5, 45 dH, cH	dH, cH scale; dilutions in Merck distilled water. Machine succussion (vigorous hitting, 70 impacts)	U, P: Merck distilled water	M, SE, Me, MAD, γ; Wilcoxon runk sum test, *t*-test	a) Decrease** by all dH potencies, especially by 45 dH b) Decrease of variability between experiments by all dH, cH potencies
Datta[57]	Mulberry/ *Meloidogyne incognita*	Not reported	3 batches of 20 plants for each treatment; 3 random samples/batch for leaf and root-protein content	3	a) Shoot length, fresh weight b) Root length, fresh weight c) Number of leaves/plant d) Surface area of leaves e) Gall number/plant f) Nematode population/ root, soil g) Leaf, root-protein content h) Analysis of residues i) *In vitro* mortality test	Foliar spray	Cina LM, 200c	c scale in 90% ethanol; final dilution 1:40 with distilled water for Cina MT, 1:20 for Cina 200c. Hand succussion (10 powerful downward strokes)	P: 1:40, 1:20 aqueous solutions of 90% ethanol	M, SE; C.D. at $p \leq 0.01$ by ANOVA, *t*-test	a) Increase** b) Increase** c) Increase** d) Increase** e) Decrease** f) Decrease** in roots, increase** in soil g) Increase** h) No toxic residues i) No effect
Shah-Rossi *et al.*[10]	*Arabidopsis thaliana*/ *Pseudomonas syringae*	b, r, s	8–13 plants	5–6	infection rate in leaves	Plunging upside down of plant; dropping in the center of the rosette; watering	30 homeopathic treatments; selected: Carbo-v, Mag-p, Nosode, Biplantol 30x, Biplantol	Potencies up to 9x in ethanol 43%, up to 30x in sterile purified water; nosode potentization in sterile purified water. Hand succussion (1 min)	S: sterile purified water 1x; P-C	M, SD; *t*-test, one- and two-way ANOVA, F test, LSD test	Reduction** by Biplantol

Table 3 (*Continued*)

Publication [reference number]	*Host/ pathogen**	*Methods†*	*Number n (per treatment and experiment)*	*Number n (independent experiments)*	*Measured parameters*	*Treatment*	*Test substance‡/ potency levels*	*Potentisation*	*Control§*	*Statistical analysis‖*	*Findings¶*
Sukul and Sukul[54]	Cowpea/ *Meloidogyne incognita*	Not reported	10 plants for each treatment; for total root protein 3 random samples from each group	2	a) Shoot length, weight b) Root length, weight c) Root nodule d) Gall number e) Nematode population/ root, soil f) Total root protein g) Absorption spectra Cina 1000 *vs.* MT h) Relaxation time (T_1) Cina 1000 *vs.* 90% ethanol	Foliar spray	Cina 1000c	c scale in 90% ethanol (potentization by 10 downward strokes), imbibition of sucrose globules then soluted in distilled water	U: aqueous solutions of globules imbebbed in 90% ethanol	M, SE; C.D. at $p \leq 0.01$ by ANOVA, *t*-test	a) Increase** b) Increase** in length and decrease** in weight c) Increase** d, e) Reduction** f) Increase** g) n.s. h) Reduction** *vs.*OH, increase** *vs.* CH_2, CH_3 groups
Sukul *et al.*[55]	Tomato/ *Meloidogyne incognita*	Not reported	2 replicates of 10 plants for each treatment	1	a) Shoot length, weight b) Root length, weight c) Gall number d) Nematode population/ root, soil e) Total root protein f) Absorption spectra Cina 1000 *vs.* MT g) Relaxation time (T_1) Cina 1000 *vs.* 90% ethanol	Foliar spray	Cina 200, 1000c	c scale in 90% ethanol (potentization by 10 downward strokes), imbibition of sucrose globules then soluted in distilled water	U: aqueous solutions of globules imbebbed in 90% ethanol	M, SE; C.D. at $p \leq 0.01$ by ANOVA, *t*-test	a) Increase** b) Increase** in length by Cina 200c and n.s. in weight c) Reduction** d) Reduction** e) n.s. f) n.s. g) n.s. *vs.*OH, increase** *vs.* CH_2, CH_3 groups
Sukul *et al.*[56]	Lady's finger/ *Meloidogyne incognita*	r	10 plants for each treatment; for leaf, root protein and root content 5 random samples from each group	2	a) Shoot length, weight b) Root length, weight c) Leaf number d) Gall number e) Root-nematode population f) Soil-nematode population	Foliar spray	Cina, Sant 30c	c scale in 90% ethanol (potentization by 10 downward strokes), final dilution 1:1000 with distilled water	N: inoculated untreated plants, uninoculated, untreated plants; P: inoculated plants treated with Ethanol 30c	M, SE; C.D. at $p \leq 0.05$ by one way ANOVA	a) Decrease** in length by Sant b) Decrease** in length by all, in weight by Cina, Sant c) Decrease** by Cina

(*continued on next page*)

Table 3 (*Continued*)

Publication [reference number]	*Host/ pathogen**	*Methods*†	*Number n (per treatment and experiment)*	*Number n (independent experiments)*	*Measured parameters*	*Treatment*	*Test substance*‡ */ potency levels*	*Potentisation*	*Control*§	*Statistical analysis*‖	*Findings*¶
					g) Leaf, root-protein content h) Leaf, root water content						d, e) Decrease** by Cina, Sant f) Increase** by Cina, Sant g) Increase** by Cina in leaves, **decrease by all in roots h) n.s. in leaves, increase** by Cina, decrease** by Sant

* Host/pathogen: TMV = tobacco mosaic virus.
† Methods: b = blinding; r = randomisation; s = systematic negative control experiments.
‡ Test substance: *Carbo-v = Carbo vegetabilis; Mag-p = Magnesia phosphorica; Sant = Santonin*.
§ Controls: U = unsuccussed potentisation medium; S = succussed potentisation medium; P: potentised potentisation medium; P-C = positive control; N = no treatment group.
‖ Statistical analysis: M = mean; SE = standard error; Me = median; MAD = mean absolute deviation; C.D. = critical difference; γ = Pearson's index of skewness; r = coefficient of correlation.
¶ Findings: n.s. = no significant differences.
** Significant difference.

theobromae (Pat.) Griffon & Maubl. (Syn. = *Botryodiplodia theobromae* Pat.), a severe pathogen that causes post-harvest rot of guava (*Psidium guajava* L.): all the tested potencies of *Arsenicum album* were found to completely suppress *in vitro* spore germination, while *Kali iodatum* and *Blatta orientalis* were always associated with better germination than the control. Arsenic potencies were then tested *in vivo* as a pre-inoculation dip treatment of guava fruits: a large reduction in fruit rot was observed (1–2% rotting in treated fruits, compared with 76% rotting in the control series). Since the treated fruits did not exhibit any phytotoxic effects, homeopathic arsenic was proposed as a safe and economical treatment for the control of post-harvest rot of guava. Subsequently, the *in vitro* effects of ten homeopathic treatments on spore germination, mycelial growth and sporulation of fungal pathogens that cause post-harvest fruit rots were reported.[21] The pathogens considered were: *A. alternata*, isolated from apple and tomato; *G. zeae*, isolated from banana and tomato; *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk (Syn. = *Colletotrichum gloeosporioides* Penz.) isolated from mango; *P. mangiferae*, isolated from mango; *P. psidii* and *Colletotrichum coccodes* (Wallr.) S. Hughes (Syn. = *Gloeosporium psidii* Delacr.) isolated from guava. Nearly all the treatments inhibited spore germination (particularly the centesimal potencies) with, in some cases, a pathogen-specific action: for example, *Thuja occidentalis* and *Blatta orientalis* were effective only against *G. zeae*, whereas *Lycopodium clavatum* and *Zincum sulfuricum* showed a very wide range of action. However, the inhibiting effect was restricted to specific ranges of potencies (in both the decimal and centesimal scale) and the magnitude of action varied depending on the potency. Some treatments were effective only in a single range (i.e. *Blatta orientalis* inhibited spore germination of *G. zeae* only in the range 146–150c), while others had a number of effective ranges (i.e. *Zincum sulfuricum* was effective against the same pathogen at 1–5, 27–32, 45–49c and 1–6x). The potencies that had maximum inhibitory action on spore germination were then further evaluated for their effects on growth and sporulation of the corresponding pathogens: in some cases the same inhibitory action was observed on both experimental variables, while in others cases only on growth. A significant correlation between inhibition of spore germination and reduction in mycelial yield was found for all the pathogens considered in the study. The same authors[22] further investigated the efficacy of particular potencies, chosen on the basis of previous studies,[21] for controlling storage rot of artificially infected fruits: *Kali iodatum* 149c against *G. zeae* of tomato (*Licopersicon esculentum* Karsten ex Farw), *Kali iodatum* 87c against *P. psidii* of guava and *Lycopodium clavatum* 190c against *P. mangiferae* of mango (*Mangifera indica* L.). In particular, the ability of some adjuvants (soap powder, wheat flour, castor oil, paraffin oil and glycerol) to improve the efficacy of the treatments was evaluated: only soap powder showed highly significant results *vs.* control (i.e. the same remedy without any adjuvant), in both pre- and post-inoculation treatments, without any damaging effects on the fruits. The effects of the treatments on the quality and palatability of the treated fruits, and the economics of their application, were also evaluated: the treatments caused a significant reduction in losses during storage, and no change in the taste and palatability of the fruit. In an attempt to explore the cause of the above-reported inhibition of fungal spore germination,[21] the same team investigated the effects of the same homeopathic treatments on the respiration and organic acid pool of the germinating spores.[23] Most of the treatments caused a marked reduction in the respiration rate, but with a magnitude of effect that varied depending on the treatment, its potency and the pathogen. Some of the treatments even brought the respiration down to zero. There was a significant correlation between the inhibition of spore germination and the rate of respiration. Also, quantitative and qualitative differences were observed between the organic acid pool of spores germinating in homeopathic treatments and that of spores germinating in distilled water. In a subsequent paper,[24] the authors report the results of an *in vivo* evaluation of the efficacy of some homeopathic treatments previously tested *in vitro*[21–23] for controlling the afore-mentioned pathogens that cause post-harvest fruit rots. The experimental protocol was the same as that of the preceding papers,[22] and the results confirm the previous findings: not all the treatments selected based on their activity *in vitro* yielded significant results when tested *in vivo*; only a few induced significant reductions in infection and fruit rotting during storage. In particular, the untreated guava, mango, tomato and apple fruits incurred losses of 67–76%, while the same treated fruits showed losses of 21–48%; in banana the difference was likewise significant, with a 60% loss for the treated fruits compared to a 100% loss for the controls. Moreover, soap powder proved to be highly effective as an adjuvant, enhancing the action of all the efficacious treatments without inducing appreciable changes in the nutritional and organoleptic properties. Another study by the same research team[25] investigated the effects of twelve homeopathic treatments in four potencies (3, 6x; 30, 200c) for controlling fruit rot in guava caused by *L. theobromae* and *Geotricum candidum* (Link). Using *in vitro* tests, an inhibition of mycelial growth was obtained with a number of treatments, but to varying extents depending on the remedy, potency and pathogen: those treatments that induced more than 30% inhibition are reported in Table 1. The most effective remedies were then tested *in vivo*, as pre- and post-inoculation dip treatments for the fruits. The best results against *L. theobromae* were obtained with *Kali bichromicum* 200c: a significant reduction of approximately 60–70% relative to the control in the percentage of infected fruits and rot development was observed for both pre- and post-inoculation treatments. The most efficacious treatment against *G. candidum* was *Lycopodium clavatum* 30c, which reduced the percentage of infected fruits and rot development in both pre- and post-inoculation treatments by about 70%. Other studies[26] investigated the effects of two homeopathic treatments (*Filix mas* and *Blatta orientalis*) in different decimal potencies (3, 6, 30, 200x) on wheat seed mycoflora (both external and internal). Although no statistical analysis is presented, some results appear to be interesting: the population of

Fusarium oxysporum Schltdl. was completely suppressed by the 30 and 200x potencies of both treatments, while that of *A. alternata* was reduced by all the tested potencies of *Blatta orientalis*. The germination of wheat seeds treated with homeopathic preparations did not vary significantly from that of untreated wheat seeds. A more recent paper[27] reports the effects of two other homeopathic treatments, *Lycopodium clavatum* and *Thuja occidentalis*, in different potencies (3, 6x and 30, 200c), on wheat seed mycoflora. This study investigated the activity of the treatments on pathogenic *F. oxysporum* on the general mycoflora of seeds as well as in the spermosphere (i.e. region of the soil influenced by germinating seeds) and the spermoplane (i.e. mycoflora associated with germinating seeds). Most of the tested potencies suppressed *F. oxysporum* populations in quiescent seeds, as well as in the spermosphere and spermoplane regions: this finding is interesting in light of the severe diseases caused by this pathogen. Moreover, all the treatments both qualitatively and quantitatively affected the general mycoflora of the seeds and of the spermosphere and spermoplane, with alterations specific to the potency and fungal form involved.

Other authors[28] studied the effect of a number of homeopathic treatments in 30 and 200c potencies against *Cochliobolus miyabeanus* (S. Ito & Kurib.) Drechsler ex Dastur (Syn. = *Helminthosporium oryzae* Breda de Haan), *Haematonectria haematococca* (Berk. & Broome) Samuels & Rossman (Syn. = *Fusarium solani* (Mart.) Sacc.) and *Penicillium decumbens* Thom. Some of the treatments showed strong toxicity against the germination of test fungi, while others accelerated it.

Another study[29] investigated the effects of 30 and 200c potencies of some preparations on mycelial growth and conidial germination of *A. alternata*, *Pseudocochliobolus pallescens* Tsuda & Ueyama (Syn. = *Curvularia pallescens* Boedijn) and *Cochliobolus australiensis* (Tsuda & Ueyama) Alcorn (Syn. = *Drechslera australiensis* Bugnic. ex Subram. & B.L. Jain). Some potencies were found to inhibit spore germination and *in vitro* growth, while others accelerated them. The same *in vitro* growth model was used by Misra *et al*.,[30] who tested fourteen homeopathic treatments in the 200c potency against *Aspergillus parasiticus* Speare: two treatments showed a stimulating effect on aflatoxin production, one had no effect, while the remaining treatments inhibited aflatoxin production by 10–80%. With respect to fungal growth, some potencies induced a reduction of up to around 65%. Subsequently, Mishra[31] tested different remedies on *in vitro* spore germination and growth of *Aspergillus niger* Tiegh, which causes storage deterioration of coriander (*Coriandrum sativum* L.) and cumin (*Cuminum cyminum* L.) seeds: the 200c potencies of *Arsenicum album*, *Calcarea carbonica*, *Graphites* and *Phosphorus* induced an inhibition of more than 90%.

Another team[32] screened different homeopathic potencies for their inhibitory effect on the growth of *A. alternata* and *Cochliobolus lunatus* R.R. Nelson & Haasis (Syn. = *Curvularia lunata* (Wakker) Boedijn), two common leaf spot pathogens that affect economically important ornamental and cultivated plants. Most of the tested treatments caused a significant inhibitory effect, though only a limited number of potencies induced 100% inhibition. The same experimental set-up was also used by Singh[33] to assess the effects of some homeopathic treatments on three keratinophilic fungi, *Nannizzia incurvata* Stockdale, *Malbranchea aurantiaca* Sigler & J.W. Carmich., *Botryotrichum keratinophilum* Kushwaha & S.C. Agarwal, in terms of radial growth and mycelial weight. Some treatments were found to inhibit *in vitro* growth of the test fungi, but the work suffers from the same shortcomings as the former paper.[32]

Another team[34] tested some remedies on the growth of *Alternaria solani* Sorauer and *L. theobromae*, obtaining antifungal effects against both fungi, though with notable variability.

The effectiveness of some homeopathic treatments on the incidence of seed-borne fungi and seed germination of reed okra (*Abelmoschus esculentus* L.) was also studied.[35] A total of 22 fungal species (not entirely reported by the authors) were isolated from the seeds; *Thuja*, *Nitric acid* and *Sulphur* 200c completely checked the growth of all the species, whereas *Teucrium* mother tincture and *Nitric acid* 30c failed to control *Aspergillus flavus* (Link), *A. fumigatus* (Fresen.), *A. niger*, *A. alternata*, *Penicillium oxalicum* (Currie & Thom), *P. granulatum* (Bainier), *Rhizopus stolonifer* (Ehrenb.) Vuill. (Syn. = *Rhizopus nigricans* Ehremb.), *Mortierella subtilissima* (Oudem). A significant increase was observed in seed germination and root/shoot length *vs.* control for all the treatments.

In another paper,[36] the effects of *Kali iodatum*, *Arsenicum album*, *Thuja* and *Blatta orientalis* (3, 30, 200c potencies) on mycelial growth, sporangial production, and pectolytic and cellulolytic enzyme activity of *Phytophtora colocasiae* Racib. were investigated, along with the ability to control leaf blight and corm rot of taro (*Colocasia esculenta* (L.) Schott) caused by the fungus. The 200c potency of each treatment proved to be the most effective; in particular, in *in vitro* experiments, *Kali iodatum* 200c produced a 90% inhibition of mycelial growth, very poor sporulation, and 65–97% inhibition of all the studied enzymatic activities (polygalacturonase, poly-methyl-galacturonase, pectin-methyl-transeliminase, poly-galacturonase-transeliminase, cellulase). *Kali iodatum* and *Arsenicum album* 200c, which yielded the most interesting results *in vitro*, were tested *in vivo* as a pre-inoculation spray on leaves of potted plants: both significantly reduced the intensity of disease, by 59 and 45% respectively.

The effects of 10 homeopathic treatments on spore germination of *A. solani* and on tomato and wheat seed germination were studied.[37] The most interesting results were obtained with *Selenium* 31c, which caused complete spore inhibition, and *Cuprum* 201, 203c, which reduced fungal germination by 40 and 50%, respectively. No effect was observed on tomato seed germination, but seedling growth was stimulated by *Sulphur* 201, 203c. On the other hand, the percentage of wheat seeds contaminated by *A. alternata* was increased by *Lycopodium* 201c, *Natrum* 202c, *Sulphur* 201c and

decreased by *Cuprum* 203c, while seedling growth showed a 50% increase with *Cuprum* 202, 203c and *Sulphur* 202c.

A Brazilian team[38] investigated the possibility of using homeopathic treatments to control apple tree powdery mildew caused by *Podosphaera leucotricha* (Ellis & Everh.) E. S. Salmon, in line with the principles of organic agriculture. Only a short abstract of the work was published: young apple plants var. Fuji, kept in plastic bags, and showing foliar symptoms of powdery mildew, were sprayed twice (at 12-day intervals) with *Kali iodatum*, *Lachesis trigonocephalus*, *Staphysagria* 30, 100c, *Sulphur* 30c and *Oidium lycopersici* 100c. The plants were evaluated one week after the last treatment, and those treated with *Staphysagria* 100c showed a significant reduction in the incidence of disease.

Plant/virus models

Other studies have looked into the effectiveness of homeopathic remedies on plant virus diseases. The papers with MIS < 5 are summarized in Table 2; most of these experiments involve a small number of replicates and data are presented without statistics.

Indian researchers[39] tested several treatments, selected from those used for human viral diseases, on tobacco (*Nicotiana tabacum* L. and *N. glutinosa* L.) plants or leaf disks inoculated with tobacco mosaic virus (TMV): an inhibitory effect on virus multiplication rate and local lesion number was observed. The same team[40] studied the effects of 12 Schüssler salts in the 6x potency on tobacco (*N. tabacum*, *N. glutinosa*) and goosefoot (*Chenopodium amaranticolor* Coste & A. Reyn.) plants inoculated with TMV. A reduction in the number of lesions in *N. tabacum* and *N. glutinosa* was obtained with pre- and post-inoculation treatments. Singh *et al*.[41] also report a reduction in the number of TMV lesions in *N. glutinosa* with post-inoculation sprays of some homeopathic treatments. A very short communication,[42] describes some remedies showing an inhibitory effect when mixed with TMV suspension and used as a spray treatment on tomato and goosefoot plants.

Khurana[43] investigated the *in vitro* and *in vivo* effects of some homeopathic treatments on papaya (*Carica papaya* L.), tobacco and goosefoot against three viruses: papaya mosaic virus (PapMV), papaya leaf distortion mosaic virus (PLDMV) and papaya ringspot virus (PRSV). A higher degree of virus inhibition was observed when the treatments were either mixed with infective sap before inoculation or administered to hosts by root-dip treatment. The treatments had more effect on systemic infections than on local lesions. In a subsequent study,[44] different plant models were used to assess the antiviral potential of some homeopathic preparations. Certain potencies of different treatments were found to reduce the average number of lesions and the percentage infection by more than 50%. Unfortunately, nothing can be said about the methodology and statistics because some pages of the paper are not available.

The effects of pre- and post-inoculation treatments using five different remedies were studied on papaya seedlings infected with PLDMV[45]: pre-infection treatments appear to be more effective than post-infection treatments in delaying onset of symptoms and reducing their severity. Shukla and Joshi[46] tested some homeopathic treatments on sorghum plants (*Sorghum vulgare* Pers.) infected with the sugarcane mosaic virus (SCMV), and claim that some of the tested treatments induced virus inhibition. Several remedies in the 30x potency were tested[47] against PapMV, which is widespread in India and causes heavy losses in papaya plants. The treatments were prepared in two concentrations (1% or 2% in water) and applied 4 times, at one-week intervals, to artificially inoculated seedlings. Visual symptoms were recorded, then the percentage disease control and confidence difference were calculated. All the treatments significantly reduced disease severity, especially *Thuja* and *Cedron* at 2%, and showed prolonged effects in the treated plants. The chlorophyll content of infected plants (very low compared to healthy plants) was also found to be increased by most of the treatments, but not to a statistically significant extent. Subsequently, the same research team[48] studied the effects of two of the previously tested homeopathic treatments (*Thuja* and *Cedron* 30x at 2% in water) in comparison with three plant extracts and three chemical compounds against TMV in tomato. The experimental protocol consisted of 7 foliar sprays applied at one-week intervals. The same treatments were also tested in a field trial (see 'Field trials' section) against cucumber mosaic virus (CMV) in bottle gourd (*Lagenaria siceraria* (Molina) Standl.). The appearance of visual symptoms on tomato plants was recorded periodically and final observations were taken one month after the last spraying. All the treatments induced a significant reduction in the mean incidence of disease, particularly *Thuja* 30x and *C. aculeatum* extract (17.3%, compared to 6.6% for the control), and significantly enhanced the yield.

A more recent paper,[49] with MIS ≥ 5 (reported in Table 3), investigates the effects of homeopathic arsenic trioxide (As_2O_3) (*Arsenicum album*) treatment on tobacco plant resistance to TMV. *N. tabacum* plants, cv. Samsun, carrying the TMV resistance gene *N*, were used for all the experiments, which were performed in a greenhouse under controlled conditions. A purified TMV-type strain suspension was used for virus inoculation, and the outcome variable was the mean number of hypersensitive lesions (necrotic spots) on leaf disks obtained from inoculated leaves following a randomized pattern and blind protocol. The remedy was selected on the basis of the hypersensitive-like reaction induced by arsenic trioxide in phytotoxic concentrations on tobacco leaves (principle of similarity, Figure 1) and treatments were prepared in decimal and centesimal Hahnemannian scales (5 and 45 potencies), starting from As_2O_3 1 mM. Statistical analyses showed significant effects for both decimal potencies *vs*. controls (unsuccussed and potentized water): in particular, As_2O_3 45dH induced a highly significant decrease in the number of lesions (about 21% *vs*. unsuccussed control, Figure 2), i.e. an improved level of host resistance. A decrease in inter-experiment variability following decimal and centesimal treatments was observed.

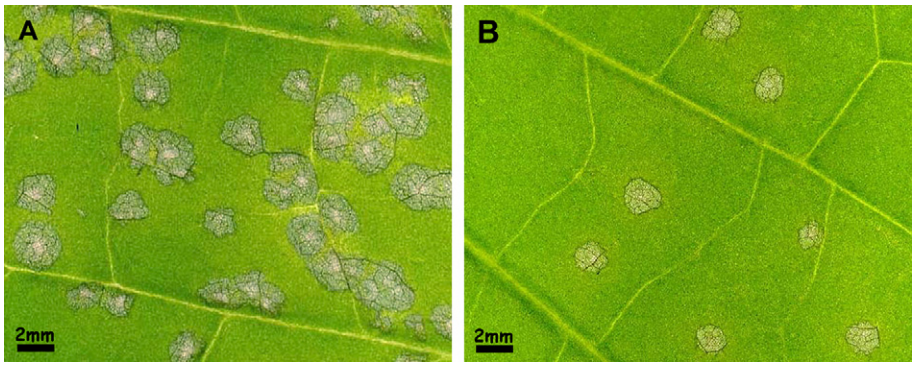

Figure 1 Principle of similarity in tobacco leaves inoculated with TMV[49]: hypersensitive lesions induced by TMV (A) and necrotic spots induced by As_2O_3 in phytotoxic concentrations (B).

Plant/bacteria models

Very few studies adopting a homeopathic approach have investigated bacterial infections. In fact, we found only one short paper and an abstract of a congress (MIS < 5, Table 2) and a very recent paper (MIS ≥ 5, Table 3). The first of these three[50] tested four homeopathic treatments on *in vitro* pineapple plants (*Ananas comosus* (L.) Merr.) against bacterial contaminations, using distilled water in the same potencies as the control. There is insufficient information about the experimental protocol, and no statistical analysis, but the results seem interesting: complete suppression of bacterial contamination was obtained with *Calendula*, *Staphysagria* and *Oscillococcinum*, while *Arsenicum album* showed a stimulatory effect on seedling growth. A sensitivity of the homeopathic preparations to sunlight was also observed. The congress abstract[51] reports positive results controlling *Xanthomonas albilineans*, associated with sugarcane in meristematic cultivation, using four homeopathic remedies, but no description is given of the experimental protocol.

The only well-structured study is the third,[10] which investigates the effects of some homeopathic treatments on *Arabidopsis thaliana* plants infected with *Pseudomonas syringae* (pv *tomato* strain DC3000, Figure 3). The experimental protocol is fully described and all the main scientific requirements are satisfied, with 5 or 6 independent experiments performed. A total of 30 homeopathic preparations (chosen on the basis of different criteria) were screened, from which five were selected for the main experiments. The plants were treated with homeopathic preparations before and after infection: only one homeopathic complex remedy (Biplantol SOS in original formulation) induced a significant reduction in the rate of infection in the leaves. The efficacy of this treatment was about 50% of that obtained with a non-homeopathic plant immunity activator such as Bion, suggesting that homeopathic formulations, if optimized further, might offer potential for treating bacterial plant diseases.

Plant/nematode models

Some papers on nematode infections have been published by Indian researchers[52,53] (Table 2;[54–57] Table 3), all of which investigate the root-knot nematode *Meloidogyne incognita* (Kofoid and White) Chitwood. A number of homeopathic treatments used to treat helminth infections in human beings were tested in the 30 and 200c potencies measuring *in vitro* larval hatching[52]: some treatments showed an inhibiting effect, while others had a stimulatory effect. Subsequently,[53] an *in vitro* study was carried out to evaluate the effects of fifteen homeopathic treatments (potencies not specified) on infective second-stage juveniles. Nematode mortalities were recorded 12,

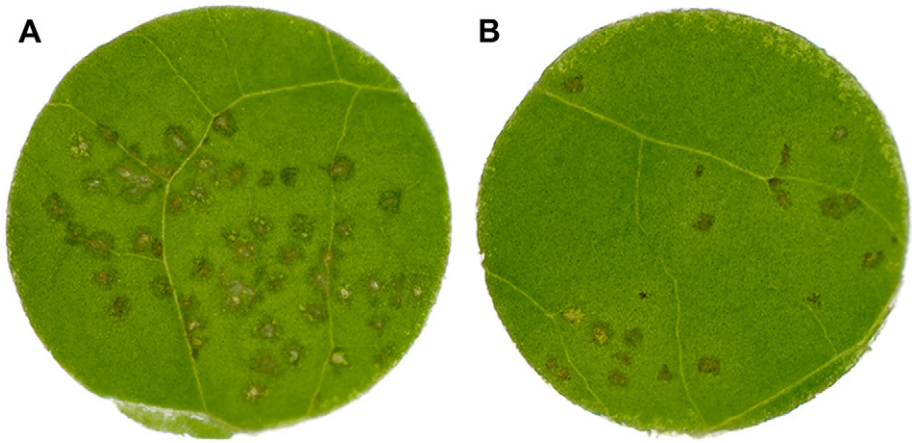

Figure 2 Hypersensitive lesions (necrotic spots) in tobacco leaf disks inoculated with TMV and treated with either water (A) or As_2O_3 dH 45 (B)[49]: homeopathic treatment (B) induces fewer and smaller lesions with respect to control (A).

Figure 3 Lesions induced by *Pseudomonas syringae* in leaves of *Arabidopsis thaliana* (see arrow).[10]

24, 36, 48 and 60 h after treatment and converted into percentages. *Arsenicum album* was found to be most toxic to the nematodes, producing approximately 100% mortality in 36 h, followed by *Thuja*, *Belladonna*, *Antimonium tartaricum* and *Cocculus* (26, 12, 11 and 10% mortality, respectively), compared to the positive control (Furadan) which induced just 5% mortality. After 48 h, *Sulphur* and *Rhus toxicodendron* also induced a higher mortality than the positive control.

Cina 1000c was tested on cowpea plants (*Vigna unguiculata* (L.) Walp) inoculated with second-stage larvae.[54] The experimental protocol is fully described, and significant results are reported in inoculated and treated plants, as compared to inoculated and untreated controls. In particular, there was found to be an increase in plant growth (in terms of shoot/root length and weight, and root length), as well as a drastic reduction in the number of root galls and the nematode population in the roots and soil. Moreover, root-protein content, significantly reduced in infected plants, was restored in the treated group. Homeopathic *Cina* showed a very similar spectral pattern to that of the mother tincture of *Cina*, whereas the spin-lattice relaxation time (T_1) was significantly reduced for OH and increased for the CH_2 and CH_3 groups in *Cina* 1000c as compared to 90% ethanol. The same research group[55] studied the effects of *Cina* 200 and 1000c on tomato plants inoculated with *M. incognita* larvae. Similar results were obtained, with more pronounced treatment effects obtained with *Cina* 200c than 1000c. Further studies have been carried out on inoculated lady's finger plants (*Hibiscus esculentus* L.), treated with *Cina*, *Santonin*, *Ethanol* 30c[56]. A significant reduction in number of root-galls, root-nematode population and root-protein content was obtained with *Cina* and *Santonin*, along with a significant increase in the soil-nematode population as compared to the inoculated and untreated controls. Moreover, *Santonin* significantly reduced root water content, whereas *Cina* induced an opposite effect.

Finally, the effects of *Cina* MT and 200c on root-knot disease of mulberry (*Morus alba* L.) have been investigated[57]: treatments were applied by foliar spraying (pre- or post-inoculation) on plants infected with *M. incognita* juveniles. Not only were inoculated and treated plants significantly less affected by nematodes, but they also showed significantly better growth for all parameters than the uninoculated controls, and improved leaf number and surface area. It is also interesting that the effects of *Cina* 200c were more pronounced than those of *Cina* MT. Pre-treatment was generally more effective than post-treatment.

Field trials

Our literature search found 9 publications describing field trials: of these, 3 did not include any statistical analysis,[48,59,60] and 2 were congress proceedings.[61,62] The 6 papers with statistics[61–66] were evaluated for their MIS, taking into account that the experimental set-up of field trials is different from that of experiments in controlled conditions. Of the MIS parameters, particular attention was given to experimental design, which was analysed according to the EPPO standards for efficacy evaluation of field trials.[67] The evaluated papers achieved scores of at least 5 points, and are listed in Table 4. A brief description of all the papers reporting field trials is given below.

The oldest work[59] studied the effect of *Tabacum* 30c on papaya plants affected by PapMV: the treatment was chosen on the basis of the principle of similarity, and an attenuation of symptomatology was observed. In McIvor,[60] fruit trees showing leaf curl symptoms were reportedly successfully treated with an isopathic 6c potency. In a field crop of bottle gourd (*Lagenaria siceraria* (Molina) Standl.) infected with CMV, two homeopathic treatments (*Thuja* and *Cedron* 30x at 2% in water), previously tested *in vitro* (Table 2), were evaluated in comparison with three plant extracts and three chemical compounds.[48] Seedlings were sprayed 7 times at one-week intervals: the final observation found a reduction in the mean incidence of disease and an enhancement in yield.

Kayne[63] reports the results of a trial on rye grass (*Lolium perenne* L.) treated with *Sulphur* 6c and a mixture of *Sulphur*, *Silicea* and *Carbo vegetabilis* 6c (chosen on the basis of the remedy picture for *Sulphur* reported in the *Materia Medica*). The choice of potency and dosage were arbitrary, and no significant effects on plant growth were found; nevertheless the work provides some useful methodological insights (i.e. importance of the choice of remedy, potency and frequency of application) for testing homeopathic treatments. In a more recent paper,[64] an isopathic treatment (from infected tomato leaves) at 30c potency was tested for controlling tomato late blight caused by *Phytophthora infestans* (Mont.) de Bary, but no significant effect *vs.* control was observed. Another study instead found an increase

Table 4 Main experimental items of papers on field trials with MIS ≥ 5

Publication [reference number]	*Crop/pathogen Crop*	*Trial design/number n (per treatment and exp)/methods**	*Measured parameters*	*Test substance†/ potency levels*	*Potentisation/ dosage*	*Control‡*	*Statistical analysis§*	*Findings‖*
Boff *et al.*[61]	Trial 1: potato (Catucha, Epagri, Monalisa, Agata, Panda genotypes)/ *Phytophtora infestans*, *Alternaria solani*, *Diabrotica speciosa* Trial 2: potato (Monalisa, Catucha, Epagri genotypes)/ *Phytophtora infestans*, *Alternaria solani*, *Diabrotica speciosa*	Trial 1: randomized block with 4 replicates Trial 2: split plot with randomized block with 4 replicates	Trials 1 and 2: yield (T ha^{-1}), disease intensity, pest intensity	Trial 1: Sil 60 cH Trial 2: Cham, Sil, Kali, Thuj, *Phytophtora infestans* 60 cH, propolis extract 0.5%	Ref.¶; dosage: 12 ml/l H_2O; application at 2 week intervals, 15 days after emergence until flowering	Trial 2: N: untreated plants; P: water 60 cH; P-C: Bordeaux mixture 0.3%	$p < 0.05$, test not specified	Trial 1: highest yield in Catucha, lowest in Agata genotypes Trial 2: n.s.
Diniz *et al.*[64]	Tomato/ *Phytophtora infestans*	Randomized block design with 5 replicates	Disease severity	Nosode (infected tissue) 30c, water-ethanol 70% mixture, Bordeaux mixture 2%	Ref.#; dosage: 10 ml/l H_2O; daily spray from sowing up to transplanting (45 times)	N: untreated plants; P-C: metalaxil	M, SE; ANOVA, Fisher test at $p < 0.05$	n.s. with nosode
Kayne[63]	Rye grass	Randomized split plot design with 2 replicates	Yield (dry matter T ha^{-1})	Sulph 6c, mixture of Sulph, Sil, Carbo-v 6c	Potentisation not reported; foliar spray at the start and after the first cut	N: untreated plants	M, SE; test not specified	n.s.
Rossi *et al.*[65]	Lettuce	Randomized block design with 5 replicates	Survival of transplanted plants	Carbo-v 6, 12, 30, 100, 200 cH	Hahnemannian centesimal dynamization in alcohol 70%; final dilution in distilled water; dosage: 0.5 ml/l; foliar spray until run off before transplantation	U: alcohol 70%; N: untreated plants	M, ANOVA, Dunnett test at $p < 0.05$	Survival** increase by Carbo-v 100 cH
Sukul *et al.*[66]	Mulberry	Block design (four plot with 25 plants each); b	Morphometric (plant height, total shoot length, number of branches, weight of 100 mature leaves, leaf yield); physiological gas exchange (net photosynthesis, stomatal conductance, transpiration, physiological water use efficiency); water status (% relative leaf water content)	Cina, CCC, DMCU 30c	Dilution 1:100 in 90% ethanol, dynamization with sonication at 20 kHz for 30 s; dosage: 1:500 with distilled water; 2 foliar sprays at a 15 days interval	P: ethanol 30c	M, SE, ANOVA at $p < 0.05$	Growth** increase Increase** of physiological gas exchange Increase** of leaf water content

Trebbi *et al.*[62]	Cauliflower/ *Alternaria brassicicola*	Randomized block design with 4 replicates; b	Mean infection level	Arsenic trioxide 35dH, bentonite 10 g/l	Hahnemannian decimal dynamization; dosage: weekly foliar spray, 3 times before and 4 times after fungal inoculation	U: tap water P-C: copper oxiclorure (0.3, 1, 3 g/l)	ANOVA, Dunnett test at $p < 0.05$	Decrease** by both the treatments

* Methods: b = blinding.
† Test substance: *Carbo-v = Carbo vegetabilis*; CCC = (2-chloroethyl) trimethyl ammonium chloride; *Cham = Chamomilla*; DMCU = 3 (3, 4-dichlorophenyl)-l, 1-dimethylurea; *Sil = Silicea; Sulph = Sulphur; Thuj = Thuja.*
‡ Controls: U = unsuccussed potentisation medium; P = pontentised potentisation medium; P-C = positive control; N = no treatment group.
§ Statistical analysis: M = mean; SE = standard error.
= Findings: n.s. = no significant differences.
** Significant difference.
☚ Farmacopéia Homeopática Brasileira II. São Paulo: Atheneu Press 1997: 118.
Prado Neto JA. Farmacotécnica Homeopática, Vol I. São Paulo: Mythos Press 1997.

in lettuce seedling survival in a field trial that tested different potencies of *Carbo vegetabilis*, achieving statistically significant levels with the 100cH potency.[65]

Indian researchers[66] tested 30c potencies of *Cina* and of two plant growth retardants (selected by the principle of similarity) on growth, physiological gas exchange and water status of mulberry: a significant enhancement of all parameters relative to the controls was observed.

Two field experiments were performed by a Brazilian team[61] to study the efficacy of homeopathic preparations for managing pests and diseases in organic farming systems of potato crops. In the first experiment, different genotypes were sprayed equally with *Silicea* 60c to evaluate yield and specific responses to pathogens (*Alternaria solani*, *P. infestans*) and pests (*Diabrotica speciosa* Germar.); in the second experiment, potatoes were sprayed with different treatments (homeopathic potencies or propolis extract) and evaluated for yield and intensity of pests and disease with respect to controls. *Thuja* 60c gave the best results, but no preparation significantly differed from another. Nevertheless, the homeopathic treatments were found to be as good, in an organic farming system, as the standard Bordeaux mixture, and without any residual effect.

Finally, a field trial on the biological control of dark leaf spot caused by *Alternaria brassicicola* (Schw.) Wiltshire in cauliflower (*Brassica oleracea* L.) was carried out.[62] This work investigated the effects of arsenic trioxide 35H (chosen by the principle of similarity) and of a mineral treatment compared to controls. Both treatments were found to significantly reduce infection level relative to an unsuccussed water control, while no significant differences were found *vs.* a positive control (copper oxychloride). These are the only significant results obtained in phytopathological field trials. They doubtless call for further investigation, but do seem to support the possibility of using potentized preparations in agriculture. What is more, since the arsenic was diluted above the Avogadro limit, it could be used in agricultural practice without introducing poisonous molecules into the environment.

Discussion

Considering all the above described papers, about half of them do not provide sufficient information to be interpreted properly; in particular, the statistical analysis is inadequate or entirely absent, the number of replicates is not specified, and the experimental methodology is often poor. Moreover, none of the studies was performed blind. The results presented in them are therefore not fully reliable, but they can still provide a starting point for more comprehensive and better controlled trials in future.

The papers with a MIS < 5 included all those investigating fungal diseases. Most of the studies were carried out by Indian researchers, and though they did yield insights concerning the specific ranges of action of homeopathic potencies[21] and the control of fruit storage diseases,[22,24,25] the research can only be considered preliminary.

Out of the few studies with MIS ≥ 5 (Table 3), those carried out by Indian researchers on root-knot diseases caused

by *Meloidogyne incognita*[54–57] gave significant and reproducible results. In particular, significant effects in different host plants (mulberry, cowpea, tomato, lady's finger) were consistently obtained with ultra high potencies of *Cina*, supporting the possibility of the application of homeopathy in agriculture. As far as viral and bacterial diseases are concerned, there were only two valid papers[10,49]: these yielded some significant results, but further research is needed.

With respect to field trials (Table 4), a number of results were reported. In some cases no significant effect was observed in the control of plant disease[61,64] or on plant growth[63]; in others, the efficacy of certain homeopathic substances was verified.[62,65,66]

The mechanism of action by which homeopathic treatments control plant diseases remains unknown, but some conjectures can be made. The likeliest way is by strengthening plants' resistance to pathogens,[11,49,55] maybe through secondary metabolism pathways. In particular, in cauliflower plants, levels of glucosinolates, a class of plant secondary metabolites typical of *Brassicacae* and involved in the plant resistance mechanisms,[68] were modified following homeopathic treatments.[62,69] Furthermore, alterations to cell membrane proteins have been suggested[56,66]: during foliar spray, homeopathic treatments come in contact with the water covering the cell membrane and may bring about a change in the water structure, influencing the passage of water through the aquaporins and the function of other integral membrane proteins.

In general, the following aspects need to be carefully considered:

Selection of homeopathic substances

In phytopathology, there is as yet no equivalent of the *Materia Medica* (i.e. a ''*Materia Phytoiatrica*''), and thus selecting the correct remedy demands much thought and intuition, unless one resorts to isopathic treatments (nosodes). Since there are no standard criteria to guide the choice of substance, different approaches can be applied. For example, in some cases[49,62] treatments were selected according to the principle of similarity (hypersensitive-like reaction induced by arsenic trioxide in phytotoxic concentrations). In Shah-Rossi *et al*.,[10] four different approaches were used: a) adaptation to plant models of the criteria used in classical homeopathy, and selection of remedies as listed in the *Materia Medica* by extrapolating from human symptoms and organs to those of plants; b) testing of a known potentized substance as an inducer of systemic acquired resistance (SAR[70]); c) use of a potentized extract of infected tissue (nosode); d) testing of different metals, since they play an important role in plant nutrition and disease resistance. Approach a) was also adopted by other authors (Kayne, Rossi *et al*.)[63,65], whereas Diniz's group[64] followed approach b). In Sukul[54–56,66] and Datta,[57] homeopathic substances were selected on the basis of their nematotoxic effect in ponderal concentrations against plant parasitic nematodes. It would thus be very desirable to have a repertory of plant diseases describing the main symptoms to assist in remedy selection, in addition to a ''*Materia Phytoiatrica*'' based on provings on healthy plants.

Choice of dilution scale

Significant effects on disease control were obtained with dilutions both above and below the Avogadro limit, and with both the decimal[10,49,62] and centesimal scales,[54–57,61,63–66] but the authors give no explanation of the selection criteria. What is more, the convention in human homeopathy is that low potencies are used for acute conditions, while higher potencies are usually used to treat chronic long-standing conditions; we do not know if a similar approach could be applied in phytopathology, and specific studies and experiments on this need to be carried out in future.

Potentisation and dose levels

Different potentisation techniques were used by different research groups: for example, succussion was performed using a specifically designed machine[49,62] or by hand, without any hard surface to assist the process.[10] There was considerable variations in the timing and amplitude: in some cases, 10 powerful downward strokes were performed between each dilution[54–57]; in others[49,65] 70 strokes were performed in 1 min, whereas in Shah-Rossi *et al*.[10] the number of strokes is not specified. Sukul's group[66] used a different potentisation technique: sonication at 20 kHz for 30 s at each dilution step. To our knowledge, no specific studies have been carried out on the effects of different potentisation methods on phytopathological models, and it would be interesting to evaluate the effects of the same potency prepared following different potentisation methods.

As far as the dilution medium is concerned, water and/or alcohol were used. In particular, water was the potentisation medium cited in Betti *et al*.,[49] whereas the Shah-Rossi group[10] used ethanol at the beginning and then water, due to the phytotoxicity of alcohol: in both studies, the homeopathic treatments, once prepared, were used without any further dilution. Otherwise, in all the studies dealing with nematodes, ethanol was used up to the final potency, which was then applied to plants after further dilution in water.[56,57,65,66] It is noteworthy that this last dilution, without any succussion, differed (1:40 or 1:1000) from those used for preparing the potencies (1:100). Another manner of applying the treatments was by means of sucrose globules soaked in the homeopathic liquid and then dissolved in water.[54,55] For what concerns the frequency of application, there are no standard guidelines for the treatment calendar; generally, foliar sprays were used, but the frequency of application differed.

Controls, blinding, randomisation

In order to identify studies that provide evidence for *specific* effects of homeopathic remedies (effects related to the diluted mother tincture and implying some sort of 'memory' of the carrier substance, e.g. water), it is important to demonstrate the absence of false-positive effects arising from the influence of laboratory or ambient conditions. For this reason, it is necessary to perform *systematic negative control experiments*.[14,58] Among the papers with MIS > 5, only one[10] documented the stability of the experimental

set-up by publishing data of systematic negative control experiments. Four studies were performed blind,[10,49,62,66] and a randomized experimental set-up was generally applied.[10,49,56,61–65]

Conclusions

Phytopathological models seem to be a useful tool for investigating the possibility of applying homeopathy in agriculture. However the results obtained must be investigated further before any real and measurable effect of the homeopathic treatments can be confirmed, as opposed to a significant effect due to chance. To this end, future studies should use with high quality set-ups which include systematic negative control experiments, blinding, randomisation, adequate statistical analysis, and appropriate controls to identify specific remedy effects. It would also be advisable to perform investigations into the potentisation process itself, and to adopt standardised potentisation techniques to permit comparisons between different studies. In general, the prospects for agrohomeopathy can be considered promising, but much more experimental work is needed, especially field trials. The results of such studies, whether successful or not, should be widely disseminated so that others can learn from them, avoiding duplication and inefficiency. Replications and multicentre trials should be carried out and published in international journals with wide circulation, to gain credibility and facilitate funding.

Acknowledgements

The authors thank Laboratoires Boiron for its collaboration and for the grant awarded to one of the Authors (Dr Grazia Trebbi). In particular, the authors wish to thank Dr Silvia Nencioni and Dr Luigi Marrari for their advice and cooperation. The sponsors had no influence whatsoever upon design, conduct, evaluation, and publication of this literature review.

References

1 Betti L, Lazzarato L, Trebbi G, Nani D. The potential and need for homeopathy research in horticulture and agriculture. In: Proceeding of the International Conference ''Improving the Success of Homeopathy: a Global Perspective''. London, 26–27 January 2006, pp 64–68.
2 Elmaz O, Cerit H, Ozcelik M, Ulas S. Impact of organic agriculture on the environment. *Fresen Environ Bull* 2004; **13**: 1072–1078.
3 Lotter DW. Organic agriculture. *J Sust Agric* 2003; **21**: 59–128.
4 Carpenter-Boggs L, Reganold JP, Kennedy AC. Biodynamic preparations; short-term effects on crops, soils and weed populations. *Am J Alternative Agr* 2000; **15**: 110–118.
5 Carpenter-Boggs L, Kennedy AC, Reganold JP. Organic and biodynamic management: effect on soil biology. *Soil Sci Soc Am J* 2000; **64**: 1651–1658.
6 Heimler D, Isolani L, Vignolini P, Romani A. Polyphenol content and antiradical activity of *Cichorium intybus* L. from biodynamic and conventional farming. *Food Chem* 2009; **114**: 765–770.
7 Reeve JR, Carpenter-Boggs L, Reganold JP, York AI, McGourthy G, McCloskey IP. Soil and winegrape quality in biodinamically and organically managed vineyards. *Am J Enol Viticult* 2005; **56**: 367–376.
8 Reganold JP. Soil quality and profitability of biodynamic and conventional farming system: a review. *Am J Alternative Agr* 1995; **10**: 36–45.
9 Marques Fonseca MC, Dias Casali VW, Cecon PR. Efeito de aplição única dos prepatarados homeopáticos *calcarea carbonica*, *kaliun phosphoricum*, *magnesium carbonicum*, *natrium muriaticum* e *silicea terra* no teor de tanino em *Porophyllum ruderale* (Jacq.) Cassini. *Cultura Homeopatica* 2006; **14**: 6–8.
10 Shah-Rossi D, Heusser P, Baumgartner S. Homeopathic treatment of *Arabidopsis thaliana* plants infected with *Pseudomonas syringae*. *SWJ* 2009; doi:10.1100/tsw.2009.38.
11 Scofield A. Homeopathy and its potential role in agriculture, a critical review. *Biol Agric Hort* 1984; **2**: 1–50.
12 Albrecht H, Van Wijk R, Dittloff S. A new database on basic research in homeopathy. *Homeopathy* 2002; **91**: 162–165.
13 Karl and Veronica Carstens-Foundation. The HomBRex—Database, www.carstens-stiftung.de/hombrex; 2005.
14 Majewsky V, Heuwieser, Shah D, *et al*. Use of homeopathic preparations in experimental studies with healthy plants. *Homeopathy* 2009. in the present volume.
15 Khanna KK, Chandra S. Control of tomato fruit rot caused by *Fusarium roseum* with homeopathic drugs. *Indian Phytopath* 1976b; **29**: 269–272.
16 Khanna KK, Chandra S. Control of guava fruit rot caused by *Pestalotia psidii* with homeopathic drugs. *Plant Dis Rep* 1977a; **61**: 362–366.
17 Khanna KK, Chandra S. A homeopathic drug controls mango fruit rot caused by *Pestalotia magnifaere* Henn. *Experientia* 1978; **34**: 1167–1168.
18 Khanna KK, Chandra S. Effect of some homeopathic drugs on the spore germination of four isolates of *Alternaria alternata*. *Indian Phytopath* 1976; **29**: 195–197.
19 Khanna KK, Chandra S. Control of leaf blight of wheat caused by *Alternaria alternata* with homeopathic drugs. *Indian Phytopath* 1977; **30**: 320–322.
20 Kehri KH, Chandra S. Control of Botryodiplodia rot of guava with a homeopathic drug. *Natl Acad Sci Lett* 1986; **9**: 301–302.
21 Khanna KK, Chandra S. Spore germination, growth and sporulation of certain fruit-rot pathogens as affected by homeopathic drugs. *Proc Natl Acad Sci India* 1987; **57**: 160–170.
22 Khanna KK, Chandra S. Further investigations on the control of storage rot of mango, guava and tomato fruits with homeopathic drugs. *Indian Phytopath* 1989; **42**: 436–440.
23 Khanna KK, Chandra S. Effect of homoeopathic drugs on respiration of germinating fungal spores. *Indian Phytopath* 1992; **45**: 348–353.
24 Khanna R, Chandra S. Homoeopathic drugs in the control of some post-harvest diseases of fruits. *J Indian Bot Soc* 1997; **76**: 169–172.
25 Khanna R, Chandra S. Homoeopathic drugs in the control of fruit rots of guava. *Proc Natl Acad Sci Lett* 1990; **60**: 345–348.
26 Khanna R, Khanna KK, Chandra S. Effect of homoeopathic drugs on seed mycoflora of wheat. *Natl Acad Sci Lett* 1989; **12**: 39–41.
27 Khanna KK. Suppression of *Fusarium oxysporum* Schlecht., a pathogen causing seedling blight and foot rot of wheat, with homoeopathic drugs. *Proc Natl Acad Sci Lett* 1993; **63**: 353–360.
28 Chaube KMR, Dixit SN, Tripathi SC. Effect of some homeopathic drugs on spore germination of certain fungi. *Natl Acad Sci Lett* 1978; **1**: 355–356.
29 Kumar R, Kumar S. Effect of certain homoeopathic medicines and fungal growth and conidial germination. *Indian Phytopath* 1980; **33**: 620–621.
30 Mishra RS, Sinha KK, Singh P. Evaluation of some homeopathic drugs against aflatoxin production and growth of *Aspergillus parasiticus*. *Natl Acad Sci Lett* 1980; **3**: 289–290.
31 Mishra N. Inhibition of *Aspergillus niger* van Tiegh. by homeopathic drugs causing deterioration od coriander and cumin seeds in storage. *Natl Acad Sci Lett* 1983; **6**: 139–141.

32 Singh BS, Gupta G. Effect of homeopathic drugs on the growth of Alternaria tenuis Auct and Corvularia lunata (wakker) Boeidjn, the common leaf spot pathogens of ornamental and cultivated plants. *Adv Homeopath* 1981;117–121.
33 Singh BG. Sensitivity of keratinophilic fungi to some homeopathic medicines. *Hahnemannian Gleanings* 1983; **50**: 154–156.
34 Dua VK, Atri DC. Effect of homoeopathic drugs on the growth of two plant pathogens. *Hahnemannian Gleanings* 1983; **50**: 411–413.
35 Saxena A, Pandey ML, Gupta RC. Effect of certain homeopathic drugs on incidence of seed-borne fungi and seed germination of *Abelmoschus esculentus*. *Indian J Mycol Plant Pathol* 1987; **17**: 191–192.
36 Aggarwal A, Kamlesh T, Mehrotra RS. Control of taro blight and corm rot caused by *Phytophtora colocasiae* homeopathic drugs. *Plant Dis Rep* 1992; **8**: 94–101.
37 Rivas E, Ceceña C, Guajardo G. Acción de 9 fármacos homeopáticos sobre la germinacion de esporas de Alternaria Solani y semillas de trigo y tomate. *Boletin Mexicano de Homeopatia* 1996; **29**: 44–46.
38 Rolim PRR, Brignani Neto F, Silva JM. Controle de oídio da macieira por preparações homeopáticas. *Fit Bras* 2001; **26**: 435–436.
39 Verma HN, Verma GS, Verma VK, Krishna R, Srivastava KM. Homeopathic and pharmacopoeial drugs as inhibitors of tobacco mosaic virus. *Indian Phytopathol* 1969; **22**: 188–193.
40 Verma HN, Awasthi LP. Effect of biochemic drugs on the infection of TMV. *Geobios* 1978; **5**: 84–86.
41 Singh BP, Gupta G, Srivasta KM. Homeopathic drugs as inhibitors of tobacco mosaic virus. *Indian J Homeopath* 1980; **4**: 301–303.
42 Khatri HL, Singh I. Biochemic salts and homeopathic drugs as inhibitors of a TMV-isolate from tomato. *Ind J Mycol Pl Pathol* 1975. S: 29.
43 Khurana SMP. Effect of homeopathic drugs on plant viruses. *Planta Med* 1971; **20**: 142–146.
44 Khurana SMP. Chemotherapeutic potential of homeopathic drugs against plant viruses. In: Proceedings of S. Hahnemanns birthday and annual function, HMAI, 11th April in Lucknow 1980, pp 29–35.
45 Abidi SMH, Srivasta KM, Gupta RP, Singh BP. Effects of some medical drugs on distortion ring spot virus of papaya. *New Botanist* 1977; **4**: 12–14.
46 Shukla K, Joshi RD. Inhibition by some homeopathic drugs of sugarcane mosaic virus in sorghum. *Sugarcane Pathol New* 1982; **29**: 48–50.
47 Cheema SS, Reddy RS, Kapur SP, Bansal RD. Comparative efficacy of homeopathic drugs against papaya mosaic virus (PapMV) as foliar spray. *Indian J Virol* 1986; **2**: 132–135.
48 Cheema SS, Kapila S, Kumar A. Efficacy of various bio-products and chemical against tobacco mosaic virus in tomato and cucumber mosaic virus in bottle gourd. *Plant Dis Res* 1992; **8**: 110–114.
49 Betti L, Lazzarato L, Trebbi G, *et al*. Effects of homeopathic arsenic on tobacco plant resistance to tobacco mosaic virus. Theoretical suggestions about system variability, based on a large experimental data set. *Homeopathy* 2003; **92**: 195–202.
50 Moreno NM, Alvarez LRG. Acciòn de 4 fàrmacos homeopàthicos en el control de la contaminaciòn por bacteria. *La homeopatìa de México* 2003; **622**: 11–12.
51 Villegas AD, Gonzales LR, Rodriguez AA, et al. Utilizaciòn de la homeopathia en el saneamiento de la escaldadura foliar en caña de azùcar a través del cultivo de meristemo. In: Proceedings of ''Nosodes 2008'' Congress, 10–12 December 2008, La Habana (Cuba), p 35.
52 Kumar R, Sharma RK. Effect of certain homeopathic medicine on larval hatching of Meloidogyne incognita (Kofoid & White) chitwood. *J Sci Res Plant Med* 1979; **1**: 15–16.
53 Ray S, Pradhan AK. Homeo-drugs show nematicidal properties against tomato root-knot nematode in vitro. *Hahnemann Gleanings* 1985;447–449.
54 Sukul NC, Sukul A. Potentized Cina reduced root-knot disease of cowpeas. *Enviroment Ecol* 1999; **17**: 269–273.
55 Sukul NC, Sinhababu SP, Datta SC, Nandi B, Sukul A. Nematotoxic effect of *Acacia auriculiformis* and *Artemisia nilagirica* against root-knot nematodes. *Allelopathy J* 2001; **8**: 65–72.
56 Sukul NC, Ghosh S, Sukul A, Sinhababu SP. Amelioration of root-knot disease of Lady's finger plants by potentized Cina and Santonin. *Homeopathy* 2006; **95**: 144–147.
57 Datta SC. Effects of Cina on root-knot disease of mulberry. *Homeopathy* 2006; **95**: 98–102.
58 Baumgartner S, Heusser P, Thurneysen S. Methodological standards and problems in preclinical homeopathic potency research. *Forsch Komplementmed* 1998; **5**: 27–32.
59 Sinha E. Agro-Homeopathy. *J Am Inst Hom* 1976; **68**: 37–40.
60 McIvor G. Letters to the Editor. *J Am Inst Hom* 1980; **73**: 43–48.
61 Boff P, Madruga E, Zanelato M, Boff MIC. Pest and disease management of potato crops with homeopathic preparations and germoplasm variability. In: Proceeding of 16th IFOAM Organic World Congress, Modena, Italy, 2008, pp 544–547.
62 Trebbi G, Fantino MG, Dinelli G, et al. Effects of homeopathic and mineral treatments on dark leaf spot caused by Alternaria brassicicola on cauliflower. In: Proceeding of 16th IFOAM Organic World Congress, Modena, Italy, 2008, pp 448–451.
63 Kayne S. An agricultural application of homeopathy. *Br Hom J* 1991; **80**: 157–160.
64 Diniz LP, Maffia LA, Dhingra OD, Casali VWD, Santos RH, Mizubuti ESG. Avaliação de produtos alternativos para controle da requeima do tomateiro. *Fit Bras* 2006; **31**: 171–179.
65 Rossi F, Tavares Melo PC, Ambrosano EJ, Guirão N, Schaminass EA. Aplicação do medicamento homeopático Carbo vegetabilis e desenvolvimento das mudas de alface. *Int J High Dilution Res* 2006; **5**: 4–7.
66 Sukul NC, Chattopadhyay S, Das C, Sukul A, Ghosh S, Sinha Babu SP. Enhancement of photosynthesis and plant growth by potentized drugs. *Environ Ecol* 2007; **25S**: 520–524.
67 European and Mediterranean Plant Protection Organization. Design and analysis of efficacy evaluation trials. *Bulletin OEPP/EPPO Bulletin* 2007; **37**: 11–24.
68 Ménard R, Larue J-P, Silué D, Thouvenot D. Glucosinolates in cauliflower as biochemical markers for resistance against downy mildew. *Phytochemistry* 1999; **52**: 29–35.
69 Betti L, Trebbi G, Marotti I, et al. Cavolfiore (*Brassica oleracea* L.) coltivato in regime biologico: valutazione fitopatologia e nutraceutica. In: Proceeding of XXXVIII National Congress of Italian Society for Agronomy, Firenze, Italy, 2009, pp 423–424.
70 Király L, Barna B, Király Z. Plant resistance to pathogen infection: forms and mechanisms of innate and acquired resistance. *J Phytopathol* 2007; **155**: 385–396.