A V A N C E S E N H O R T I C U L T U R A – R E V I E W

Agrohomeopathy: New tool to improve soils, crops and plant protection against various stress conditions. Review

Agrohomeopatía: Nueva herramienta para mejorar la protección de suelos, cultivos y plantas frente a diversas condiciones de estrés. Una revisión

Prieto Méndez, J.[1]; Prieto García, F.[*2]; Hernández Pérez, A. D.[2]; Quijada Morales, L. M.[2]; Aquino Torres, E.[1] & Acevedo Sandoval, O. A.[1]

[1] Academic Area of Agronomy. Institute of Agricultural Sciences, Mexico.
[2] Academic Area of Chemistry. Institute of Basic Sciences and Engineering. Autonomous University of the State of Hidalgo, Pachuca-Tulancingo Highway, km 4.5, Pachuca, Hidalgo, Mexico.
*Corresponding Author: E-mail: prietog@uaeh.edu.mx

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ABSTRACT

Prieto Méndez, J.; Prieto García, F., Hernández Pérez, A. D.; Quijada Morales, L. M.; Aquino Torres, A. & Acevedo Sandoval, O. A. 2021. Agrohomeopathy: New tool to improve soils, crops and plant protection against various stress conditions. Review. Horticultura Argentina 40 (101): 43-58.

Homeopathic treatments influence growth, production of secondary metabolites, essential oil yield, phytochemical profile, and tolerance to salt stress, among others, when applied to various crops. Homeopathic ultra high dilution is used safely for various purposes (seed germination, soil health improvement, seedling growth, flowering, fruiting, disease protection and to overcome environmental stress). Proper selection of Homeopathy medicament for each case is very important, to have hight efficiency and profitability. The agrohomeopathy can increase farmers' income by reducing the cost of use chemical fertilizers and insecticides. Literature articles on research related to the use of homeopathic preparations in plant cultivation were collected. Their impact on growth, yield, essential oil composition and tolerance to salt stress was emphasized. Various publications in which homeopathy was applied to various crops and its use increased crop yield, production of secondary metabolites (coumarins, alkaloids, phenylpropanoids), absorption and growth of nutrients in medicinal plant species, as well as tolerance to saline stress. Therapeutic treatments for human and animal health are shown to be important for various plant crops. The application of homeopathic preparations is an alternative for plant growth, friendly to the environment. It is also affordable for farmers and researchers, however more studies are required to improve its influence and effects.

Additional Keywords: agroecology, homeopathy, secondary metabolites, salt stress, agriculture.

RESUMEN

Prieto Méndez, J.; Prieto García, F., Hernández Pérez, A. D.; Quijada Morales, L. M.; Aquino Torres, A. & Acevedo Sandoval, O. A. 2021. Agrohomeopatía: Nueva herramienta para mejorar la protección de suelos, cultivos y plantas frente a diversas condiciones de estrés. Una revisión. Horticultura Argentina 40 (101): 43-58.

Los tratamientos homeopáticos influyen en el crecimiento, producción de metabolitos secundarios, rendimiento de aceites esenciales, perfil fitoquímico y tolerancia al estrés salino, entre otros, cuando se aplican a diversos cultivos. La dilución homeopática ultra alta se usa de manera segura para varios propósitos (germinación de semillas, mejora de la salud del suelo, crecimiento de plántulas, floración, fructificación, protección contra enfermedades y para superar el estrés ambiental). La selección adecuada de medicamentos homeopáticos para cada caso es muy importante, para tener una alta eficiencia y rentabilidad. La agrohomeopatía puede incrementar los ingresos de los agricultores al reducir el costo del uso de fertilizantes e insecticidas químicos. Se recopilaron artículos de literatura sobre investigaciones relacionadas con el uso de preparaciones homeopáticas en el cultivo de plantas. Se enfatizó su impacto en el crecimiento, el rendimiento, la composición del aceite esencial y la tolerancia al estrés salino. Varias publicaciones en las que se aplicó la homeopatía a diversos cultivos y su uso aumentó el rendimiento del cultivo, la producción de metabolitos secundarios (cumarinas, alcaloides, fenilpropanoides), la absorción y crecimiento de nutrientes en especies de plantas medicinales, así como la tolerancia al estrés salino. Se ha demostrado que los tratamientos terapéuticos para la salud humana y animal son importantes para diversos cultivos vegetales. La aplicación de preparados homeopáticos es una alternativa para el crecimiento vegetal, amigable con el medio ambiente. También es asequible para agricultores e investigadores, sin embargo, se requieren más estudios para mejorar su influencia y efectos.

Palabras claves adicionales: agroecología, homeopatía, metabolitos secundarios, estrés salino, agricultura.

1. Introduction

There is ongoing debate among stakeholders about the future development of agricultural and food systems to meet the global challenges of food supply, biological and cultural diversity, climate change, and social justice. Among other options, agroecology and organic agriculture are discussed (Mazón-Suástegui *et al.*, 2020). Both have similar goals and use a systems approach; however, they are recognized and received differently by stakeholders (Migliorini and Wezel, 2017).

Organic agriculture and agroecology are in many parts quite similar in principles and practices, with the main differences currently being in production with certification and use of chemical pesticides and fertilizers. Regarding principles, EU organic regulations mainly focus on the restriction of external inputs and the limitation of chemical inputs. Agroecology has a defined set of principles for ecological management of agri-food systems and also includes some socio-economic principles (Migliorini and Wezel, 2017; Nelson *et al.*, 2019; Mejías, 2019; Mazón-Suástegui *et al.*, 2019, 2020).

Applied homoeopathy research in agriculture is also finding place. The mode of action of

homoeopathy medicines and *Simillimum* of drug pictures for use in agriculture; basic principles of homoeopathy and drug administration are being discussed. Significant results have been observed using homoeopathic medicines as *Silicea terra* 12CH, *Dulcamara* 30CH and *Sulphur* 6CH to fight stress caused during wet weather and also during hot and dry conditions. Research results in improving germination and growth; pest control, disease and viral infection, etc. on various crops have been reported. Plants are unique when compared to humans and animals and need different approach. The science of homeopathy has great potentials and could give a new direction that requires attention of the researchers in alternative agriculture (Singhania & Singhania, 2014; Rîndaşu *et al.*, 2017).

Some abiotic stress control pathways (saline stress, drought stress, cold stress, metal toxicity, mechanical damage, etc.) are more expensive or less efficient. The proper selection of homeopathic medicines can be cost effective and very efficient in terms of tolerance to abiotic stress in various crop species. The *similia* principle has been shown to be very helpful in overcoming abiotic stress in plants. Ultra-high dilution of homeopathic medicines can be safely used for various purposes (seed germination, soil health improvement, seedling growth, flowering, fruiting, disease protection and to overcome environmental stress). Although homeopathic medicines have a high degree of safety and innocuity (Ortiz-Cornejo *et al.*, 2017), a proper choice of homeopathic medicines and their potency, and a proper dilution of the medicine with water should be selected. Incorrect selection could show detrimental effects on crops and it is believed that a higher dilution of drugs (1: 500 or 1: 1000) with water is more effective for plants with letals effects on crops and it is believed that a higher dilution of drugs (1: 500 or 1: 1000) with water is more effective for plants (Sen *et al.*, 2018). Proper selection of the drug and its potency can be an efficient and very profitable alternative that can increase farmers' income by reducing the cost of chemical fertilizer and insecticide inputs.

Medicinal plants are important for human health maintenance; it is considered the most affordable therapeutic treatment used by 80% of the population (Moreira, 2010). The cultivation of medicinal plants needs to be based on agroecological agriculture, without the use of synthetic chemical products that contaminate the soil, the environment and those plants that have therapeutic purposes (Willer *et al.*, 2010; Santos *et al.*, 2014; Monzón *et al.*, 2020).

Therefore, there is an increase in the number of farmers and researchers seeking natural and ecological alternatives with the aim of obtaining medicinal plants free of chemical residues (Brasil, 2011; Moreno, 2017), as well as for other crops such as vegetables. In addition to the improvement in growth, it also increases the production of secondary metabolites, essential oils and phytochemicals of pharmacological and biological interest (Moura *et al.*, 2017; Nunes *et al.*, 2018) and improvements to the quality of the soils (Morales-Barbosa, 2013; Andrade *et al.*, 2006; Sen *et al.*, 2018). Homeopathy proves to be a tool for the recovery of soil balance, mainly when applied in synergy with other ecological techniques, which rescue the vitality of the system. However, more research is needed to better understand the mechanism of action and the process of restoring this balance. Homeopathy can contribute to improve both the quality of the soil and harmonize the ecological relationships in the system.

The use of homeopathy in agriculture has been changing conventional agriculture to agroecological (Andrade *et al.*, 2011; Nelson *et al.*, 2019), through the application of homeopathic preparations in different dynamization, following the Homeopathic Pharmacopoeia guidelines proposed by Hahnemann in 1810 (Hahnemann, 2013). The homeopathic dynamizations follow the principles of disintegration of matter and radiation without nuclear rupture, through the mechanical action on the smaller particles and addition of inert substances with dynamic activity, following the laws of electromagnetic waves: frequency, length and amplitude (Bonato, 2008; Abasolo Pacheco *et al.*, 2020c; Cukaci *et al.*, 2020).

Homeopathic preparations can be applied on the soil and/or on the leaves (Wyss *et al.*, 2010;

Santos *et al.*, 2011; Andrade *et al.*, 2012). These preparations can increase or decrease the production of bioactive substances due to its influence on the primary and secondary metabolism of medicinal plants modifying its phytochemical profile (Capra *et al.*, 2014; Verdi *et al.*, 2016). The application of nosodes and biotherapeutics are the most applied techniques in agrohomeopathy (Ruíz Espinosa, 2001; Jãger *et al.*, 2010; Meneses Moreno, 2017; Moreno *et al.*, 2018).

The extensive use of synthetic nitrogen fertilizer in agriculture is causing environmental problem. In this situation it is desirable to find out suitable agents, which would increase plant growth without compromising with the quality of food and of soil. High level of salinity deteriorates seed germination, growth and yield of crops in cultivated lands. There is no effective remedy to mitigate this global problem.

The present review aims to compile the basic research in homeopathy existing in the literature applied to different crops and to verify its influence on the plant growth, phytochemical profile, yield and composition of the essential oils. It is important to analyze the options of its applications in soils and assess the possible improvements in their quality indicators, which is still somewhat insipient.

2. Materials and methods

All this bibliographic research was carried out by means of a compilation of publications from the Web of Science, Scopus and PubMed databases that evaluated applications of homeopathic preparations for the growth of medicinal plants and various crops. Different keywords related to this topic were used, such as medicinal plants + homeopathy + crops + secondary metabolism + soil + saline stress + tolerance + essential oil. The objectives, results and conclusions sections of the articles found were analyzed for the writing of this review.

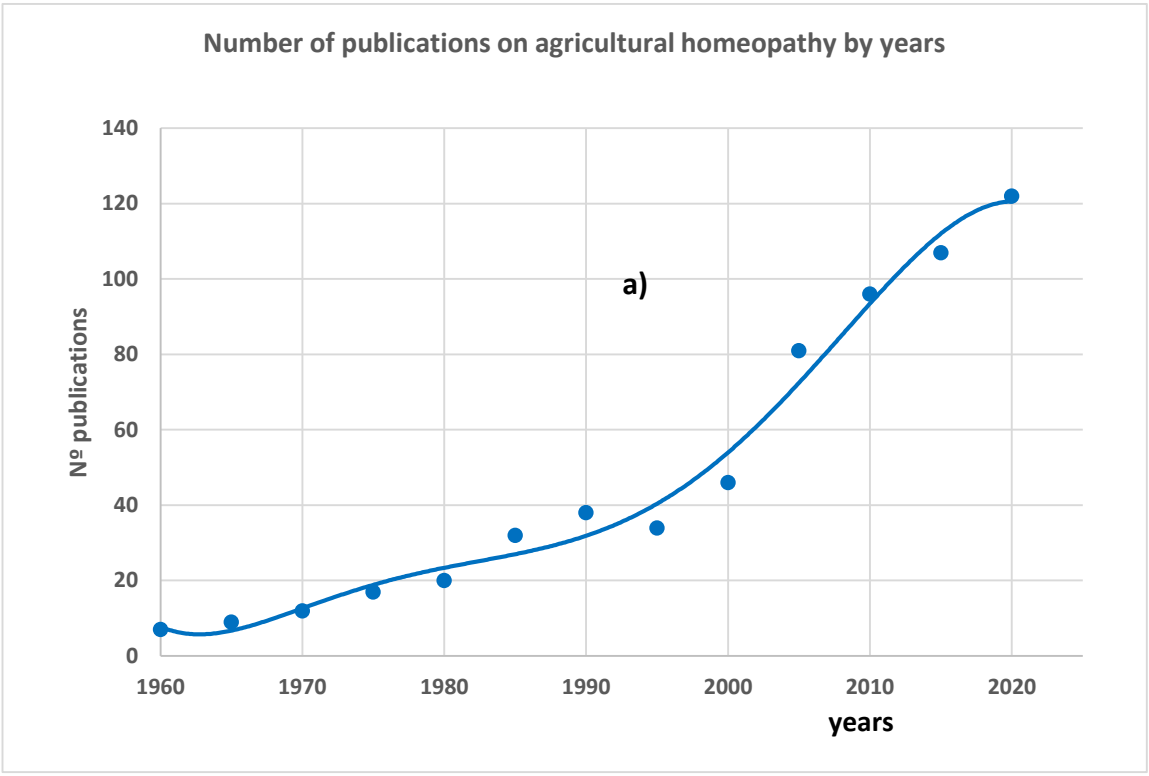
Scientific articles, term paper, master's degree dissertation and doctoral thesis that researched the application of homeopathic preparation in the soil, leaves pulverization and evaluated its influence on the growth, essential oil yield and phytochemical profile were included in this review.

One aspect to highlight in this review is that not many scientific works have been found on homeopathic applications directly to soils (Sen *et al.*, 2018) and to evaluate in these, improvements in quality indicators, improvements in their physicochemical properties (Morales Barbosa, 2013). Today, we also begin to talk not only about the quality of the soils, but also about their health. According to Doran & Zeiss (2000), soil health is the ability of the soil to function as a living, vital system, within the limits of the ecosystem and land use, to sustain plant and animal productivity, maintain or improve quality, water and air, and promote plant and animal health (Morales Barbosa, 2013). Despite being evident that the soil responds to the preparations homeopathic, these evidences are not strong enough to conclude on the final result of the homeopathic treatment in the improvement of the quality of the soil, probably attributable to the response times that are required to generate perceptible changes to the tools used.

3. Results and discussion

A literature search was carried out to compile the studies that provided information on homeopathy, homeopathic medicines, medicinal plants for homeopathic purposes, agro-homeopathy and improvements in the quality of soils by homeopathic applications. For this, the search engines Scopus and academic Google were used. For the search, the keywords were

used: agroecology, homeopathy, secondary metabolites, salt stress, agriculture, among others.
The search included studies from 1960, date in which the first studies on the "green revolution" began to emerge, until December 2020, obtaining a total of 621 references, which were compiled in a Ris file, for later management in the EndNote 9 reference software (Figure 1 a). In order to find specific information from the information, with the EndNote software Four Smart Groups were generated. With the most outstanding information, the most prominent references were selected for their analysis, from which 3 reviews and 50 articles stand out. This work was structured with this information.
As a result of using agrochemicals, there have been more reports of diseases, including, among others, leukemia, cancer, births with malformations, and abortions. For these reasons, there has been an increase in the number of producers and researchers searching for natural and ecological alternatives to be used in agriculture, with the aim of obtaining healthy and toxin free foods and eliminating the use of agrochemicals. One of the alternatives that the farmers and researchers are applying, and is becoming increasingly popular, consists of applying Homeopathy in agriculture (Agro-homeopathy). Several countries are currently applying this new option in the search for solutions to combat and control diseases in crops of economic importance, caused by bacteria, fungi, viruses and plagues, as well as boosting seed germination and the vigour of the plants. This also includes decontamination of the soils that have been exposed to agro-toxic treatments. In this work, as study is presented on the main results obtained up until now by the researchers and producers in Agro-Homeopathy, as well as the importance of botanical models in the search to find the mechanism of action in homeopathy in humans. A comparison is also made between the results obtained and with the application of agrochemicals.
Homeopathic research databases indicate that more than 1000 publications were indexed, in 2016 alone. The publications are indexed according to the type of study such as fundamental, clinical, veterinary, agricultural, etc. This is surely an authentic and scientific answer to skeptics and non-believers of homeopathy. Figure 1 b illustrates these data.
As can be seen, 11.6% of all of them are focused on applications in agriculture, demonstrating that this is an energetic field for these applications closely related to environmental aspects. Twenty one studies carried out between 2002 and 2020 were found in this search, which evaluated the influence of homeopathic preparation in the cultivation, essential oil yield and phytochemical profile of 11 medicinal species (Table 1).



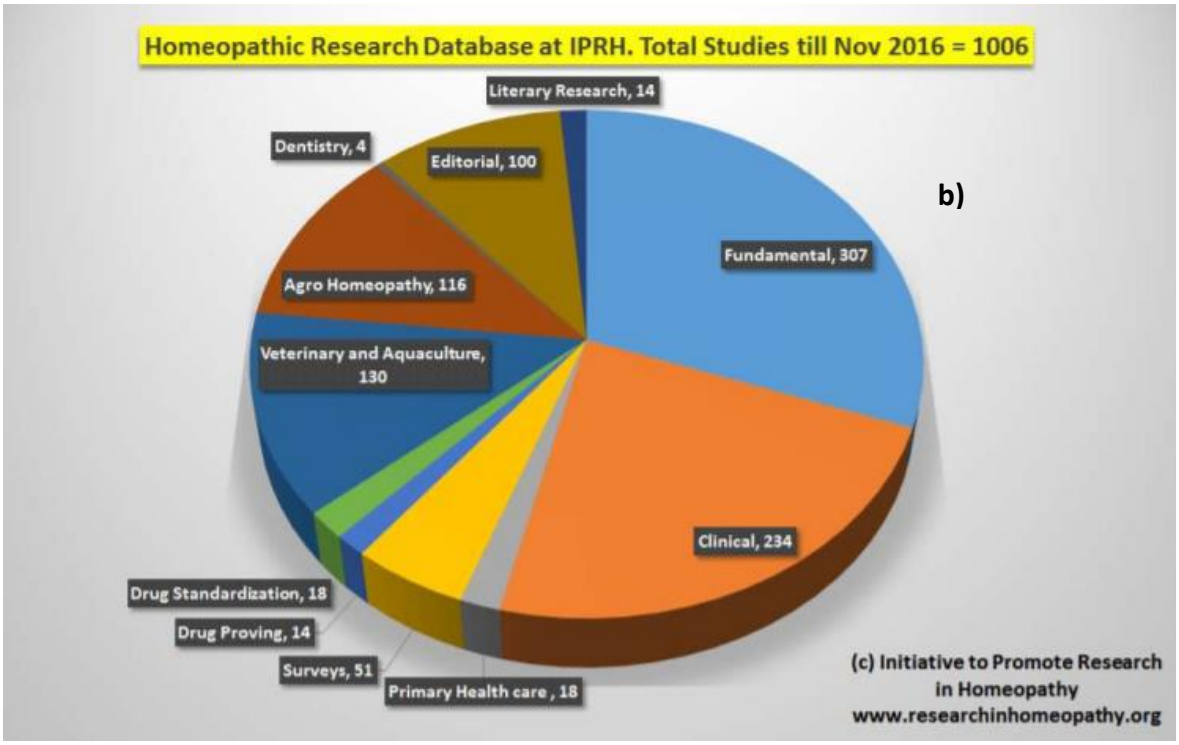


Figure 1: a) Number of publications on agricultural homeopathy by years (1960-2020). b) Homeopathy research report in 2016 alone (Karin *et al.*, 2016)

Figura 1: a) Número de publicaciones sobre homeopatía agrícola por años (1960-2020). b) Informe de investigación sobre homeopatía solo en 2016 (Karin *et al.*, 2016)

The studies analyzed nineteen homeopathic preparations in different dynamizations, being *Phosphorus, Sulfur and Silicea terra* the most studied ones (Almeida, 2002; Castro, 2002a, 2002b, Castro *et al.*, 2003; Carvalho *et al.*, 2003; Armond *et al.*, 2003; Duarte, 2007; Bonato *et al.*, 2009; Gonçalvez, 2010; Santos *et al.*, 2011; Capra *et al.*, 2014; Ponce, 2015; Verdi *et al.*, 2016; Nelson *et al.*, 2019; Mazón-Suástegui *et al.*, 2019; Abasolo-Pacheco *et al.*, 2020a, 2020b, 2020c).

The researchers also observed that homeopathic preparations can improve photosynthetic rates through changes in physiological mechanisms, since the allocation of higher levels of photo assimilated compounds in the leaves promoted growth (Bonato *et al.*, 2009; Andrade, 2012; Pereira *et al.*, 2019). Figure 1 b summarizes some of the areas of application of homeopathic preparations in plant cultivation.

Table 1: Abstract of medicinal plants species elicited by boosted homeopathics.

Tabla 1: Resumen de especies de plantas medicinales provocadas por homeopáticos potenciados.

Objective species	Application via	Homeopathic medication	Evaluated response parameter	Best treatment	Results	Authors
Ocimum basilicum L.	Soil	*Arsenicum album, Carbo vegetabilis, Calcarea carbonica, Phosphorus, Sulphur, Silicea terra* and *Cuprum metallicum* 30 CH	Essential oil In leaves	*Phosphorus* 30CH	*Sulphur 30 CH* (52.73%), *Calcarea carbonica 30CH* (47.37%) and *Carbo vegetabilis 30 CH* (27.27%): < Essential oil; *Phosphorus 30 CH*: > Essential oil (130%)	Almeida (2002)
Cymbopogon citratus L.	Soil and leaf	Humic acid, Isoterapic and *Sulphur* (3, 12, 30, 200 and 1000 C), control	Essential oil, concentrations of neral, geranial and citral In leaves	*Sulphur* and Isoterapetutic 12 C	*Humic acid 12 C and Sulphur 12 C*: > Rates of the neral and geraniol; *Sulphur 30 C*: > Rates of the neral; *Isoterapic 12 C*: > Bioomass and essential oil	Castro (2002a)
Justicia pectoralis Jacq.	Soil and leaf	Humic acid, Isoterapic and *Sulphur* 3, 12, 30, 200 and 1000 CH	Methanolic extract and coumarin content In leaves	*Sulphur* and Isoterapeutic 200 C	*Sulphur 30 C*: > rates of the methanolic extract; *Humic acid 12, 30 and 200 C*: > Coumarin content; *Humic acid 200 C*: > Coumarin in (353%)	Castro (2002b)
Ageratum conyzoides L.	Soil	*Ageratum conyzoides* L. (2, 4, 6, 30, 60 and 200 C.	Growth, essential oil and Coumarin content In leaves	*Ageratum conyzoides* L. 2, 6 and 30 CH	*Ageratum conyzoides L. 30 C and 4C whole plant*: < Essential oil; *Ageratum conyzoides L. 2 C whole plant*: > Essential oil (62%); *Ageratum conyzoides L. 6 C and 30 C root*: > Coumarin content	Duarte (2003)
Cymbopogon citratus L.	Soil	Humic acid (AH), isoterapic *Cymbopogon citratus* L. (ISO) and Sulphur (S) (3, 12, 30, 200 and 1000 C)	Essential oil In leaves	*Cymbopogon citratus* L. 6 C and 12 C	*Cymbopogon citratus L. 6C and 12 C*: positive effect; *Cymbopogon citratus L. 200 C*: negative effect	Castro *et al.*, (2003)
Tanacetum parthenium L.	Soil	*Arnica montana* (1 DH, 2 DH, 3 DH, 4 DH and 5 DH)	Fresh biomass and parthenolide content In leaves	*Arnica montana* 1, 2, 4 and 5 DH	> Plant height < Parthenolide content	Carvalho *et al.* (2003)
Bidens pilosa L.	Soil	*Alumina* 3CH, *Nitricum acidum, Natrum muriaticum, Calcarea carbonica, Calcarea phosphorica, Sulphur, China Officinalis, Magnesia carbonica* . Control: 70% ethanol and distilled water. *China Officinalis* 2, 4, 8, 10, 12, 14, 16, 18, 20, 22 and 24 CH	Morphological response, essential oil content, catalase and peroxidase enzymatic activity, production of antimalarial compounds In leaves	*China Officinalis* 3CH	*China Officinalis 3 CH*: > Fresh biomass Enzymatic activity of peroxidase and catalase was not influenced by homeopathic preparations	Armond *et al.*, (2003)

Tanacetum parthenium (L.) Schultz-Bip	Soil	*Natrum muriaticum* 2 CH	Proline	*Natrum muriaticum* 2 CH	> Chlorophyll and proline levels	Carvalho *et al.*, (2004)
Bidens pilosa L.	Soil	Solutions from *China Officinalis*	Growth, flavanoid levels, acetylene and essential oils No data	Solutions from *China Officinalis*	Changes on the phitochemical spectrum	Armond *et al.*, (2005)
Tanacetum parthenium (L.) Schultz-Bip	Soil	*Arnica montana*	Partenolides In dry aerial part	*Arnica montana*	Height and fresh mass haven't been modified cause of the solutions < Partenolide levels 3 CH and 5 CH	Carvalho *et al.*, (2005)
Eucalyptus citriodora & Eucalyptus globulus	Soil	*Phosphorus* 3, 6, 12, 30, 100, 200, 1000 and 5000 CH	Growth and essential oil	*Phosphorus* 12 CH	Essential oil	Duarte (2007)
Mentha arvensis L.	Soil	*Sulphur* 3 and 5 CH; *Arsenicum* 3 CH	Essential oil In leaves	*Arsenicum* 3 CH	Sulfur Boosted > Essential oil levels 34% and 21% *Arsenicum* > Oil rates in 45 and 21%, for 24 and 30 CH >Photosynthetic rates	Bonato *et al.*, (2009)
Talinum triangulare (Jacq.) Willd (Portulacaceae)	Soil	*Phosphorus* 3, 6, 12, 30 and 100 CH	Production of flavanoids and antioxidant capacity of the plant extract In leaves	*Phosphorus* 3, 12 and 30 CH	>Content of flavonoids >Antioxidant activity	Gonçalvez (2010)
Verbena gratissima	Soil essential	*Phosphorus* 9 CH	Growth and oil In leaves	*Phosphorus* 9 CH	>Growth, fresh biomass. influenced the composition of the essential oil with increase of beta-pinene acetate, trans-pinocarveol, trans-pinocamphone and trans-pinocarvyl acetate	Santos *et al.*, (2011)
Justicia pectoralis Jacq.	Pulverization	*Justicia*	Morphologic features, coumarin levels, electromagnetic field In leaves	*Justicia*	*Justicia*, *Arnica montana*, *Phosphorus* > Coumarin levels 54.35%; Humic Acid > 55.10% *Justicia*	Andrade *et al.* (2012)
Baccharis trimera (Less.) DC.	Pulverization Leaf	*Silicea terra* 6, 12 and 30 CH; *Silicea terra* 7 DH; *Equisetum* 7 DH	Fresh and dry biomass, quercetin content In leaves	*Silicea terra* 6 CH, 7 DH and *Equisetum* 7 DH	*Silicea terra 6CH and 7 DH*: > Quercetina content 30% and 47%, respectively; *Equisetum 7 DH*: > Quercetina content (45%)	Capra *et al.* (2014)
Ocimum basilicum L.	Pulverization Leaf	*Silicea terra* 7, 12 and 30 CH and *Equisetum* 12, 14 and 16 CH	Essential oil In leaves	*Silicea terra* 30 CH	> Essential oil yield 141%	Verdi et al. (2016)
Cucumis sativus	Liquid treattments in seeds, irrigation in soil	*Silicea terra* 7 and 13 CH; *Natrum muriaticum* 7 and 13 CH	Germination rate, germination and emergence (%). Lenght of stem and radicle. Fresh and dry weight of the aerial part and radicle. Stem diameter and number of leaves and flowers.	*Silicea terra* 7 and 13 CH; *Natrum muriaticum* 7 and 13 CH)	Higher germination (53.33%) with *Arsenicum album* 13 CH; longest stem length (107.07 cm) with *Natrum mjuriaticum* 13 C; longer radicle length (49.59 cm) with *Silicea terra* 7 CH, higher fresh weight radicle with *Magnesia phosphorica* 13 CH and greater stem diameter, number of leaves and flowers with *Natrum muriaticum*	Abasolo-Pacheco *et al.* (2020a)
Brassica napus L	Liquid treatments in seeds; irrigation	*Silicea terra 7 and 13 CH; (SiT), Natrum muriaticum 7 and 13 CH; Phosphoricum acidum 7 and 13 CH; .*	Germination and emergence (%), length of stem and radicle, fresh and weight of the aerial part and radicle. Vegetative development: height of the plant, stem diameter, number of leaves, weight, leaf area, and	*Silicea terra* 7 CH; *Phosphoricum acid* 7 CH and *Natrum muriaticum* 31 CH	Germination: higher (100%) with *Silicea terra* 7 CH and *Phosphoricum acid* 7 CH versus control (83.5%). increased stem growth during germination (3.40 cm) with *Phosphoricumn acid* 7 CH and *Natrum muriaticum* 31 CH. Emeregence: increased root growth (4.07 cm) with *Natrum muriaticum* 7 CH.	Abasolo-Pacheco *et al.* (2020b)

			productive yield.		Vegetative development: higher biomass production with *Natrum muriaticum* 7 CH. Higher profitability of cultivation (71.33%; benefit / cost of 1.7%) with *Silicea terra* 7 CH.	
Solanum lycopersicum L	Liquid treatments in seeds; irrigation in 4 m^2 plots	*Silicea terra* 7 and 13 CH; *Natrum muriaticum* 7 and 13 CH; *Zincum phosphoricum* 7 and 13 CH; , *Phosphoricum acid*7 and 13 CH	Germination: Percentage and rate of germination and emergence. Initial development: Plant height, length root, wet and dry weight. Vegetative development: Stem diameter, wet and dry weight of leaves, number of branches, leaves and flower buds.	*Silicea terra* 7 CH, *Phosphoricum acid* CH and *Natrum muriaticum* -13 CH; *Zincum phosphoricum*P-7 CH	Germination: longer stem length with *Zincum phosphoricum* 7 CH (5.5 ± 0.98 cm) versus control (4.3 ± 1.10 cm). Emergence: longer stem length with *Silicea terra* 7 CH (6.6 ± 1.11 cm) and *Zincum phosphoricum* 7 CH (5.9 ± 1.41 cm). Vegetative development: Longer stem length (94 ± 8.31 cm), number of leaves (131 ± 27.71), production of fresh and dry biomass and number of flower buds (6 ± 7.10), with *Phosphoricum acid* 7 CH.	Abasolo-Pacheco *et al*. (2020c)
Phaseolus vulgaris L., variety Quivicán	Liquid treatments in seeds, stem and leaves	*Magnesium metallicum* 31 CH; *Magnesium-Manganum phosphoricum* 3 CH; *Magnesium metallicum* 31 CH + *Magnesium-Manganum phosphoricum* 3 CH	Plant growth and development; Fresh and dry biomass	*Magnesium metallicum* 31 CH + *Magnesium-Manganum phosphoricum* 3 CH	Increases in: Stem length (47.14%) and root (30.27%); fresh root biomass (13.57%), leaves (68.36%) and stem (11.88%); dry biomass leaves (84.72%) and stem (36.11%); leaf area (21.74%); stem diameter (39.54%) and number of leaves (16.66%).	García-Bernal *et al.*, (2020)
Bacopa monnieri	Soil	Zinc sulphate (1-6 CH)	Fresh and dry biomass No data		Growth promotion	Modolon *et al.*, (2012). Kumar *et al.*, (2020)

DH = Hahnemanian decimal dilution; CH = Hahnemanian centesimal dilution

Many researchers across the world found that some homeopathic drugs can increase the rate of seed germination of different plant species. But they functionally vary according to their potency and dilutions. Biotic stresses are mainly associated with plant diseases. There are various causative agents for plant diseases- fungus, bacteria, virus, insects etc. To control these disease-causing agents, some researchers used potentized homeopathic drugs successfully. (Sen *et al.*, 2018).

In homeopathy a substance, which produces morbid symptoms at high doses on healthy individuals, ameliorates the disease in a patient showing similar symptoms at ultra-low doses. During the last years, it has been observed that, certain plant growth retardants promote growth of crops at ultrahigh dilutions (Mondal, 2016).

Abiotic stresses may of different kinds, i.e.- Salt stress, heat stress, cold stress, drought stress, metal (copper, nickel, lead, cadmium, arsenic etc.) toxicity etc., abiotic stresses are caused by various abiotic environmental factors and there are many methods of eradicate these stress conditions (Sukul *et al.*, 2012; Mondal *et al.*, 2012).

However, it is very interesting that there were no reports of its applications to crop soils or applications to improve its properties and qualities.

According to Ramzam (2015) the synthesis of glucose molecule through physiological processes (photosynthesis and respiration) produces organic compounds (sucrose). In addition to providing energy for plant growth and development they also act on the precursors of shikimic acid and acetate. These precursors form the mevalonate (MEV) and 1-Deoxy-D-xylulose 5-phosphate (DXP) pathways. These pathways are the origin of some secondary metabolism categories such as flavonoids, tannins, alkaloids, phenolic compounds, terpenoids

and others.

The homeopathic application of *Natrum muriaticum 2cH* via soil increased the content of chlorophyll in the leaves of *Tanacetum parthenium*; it also increased the photosynthetic rates and the biomass production (Carvalho, 2004). The same homeopathic preparation applied during the cultivation of *Mentha arvensis* (Carvalho, 2004) changed the photosynthetic rates of this species. These results can be related to the higher number of chlorophyll molecules that increases the capacity of light absorption and induces rubisco activity, leading to higher carbon absorption. This increases the synthesis of fundamental compounds for the secondary metabolism, which are responsible for the production of bioactive molecules with therapeutic properties.

Biotic and abiotic factors are related to plant growth, the physiology and biochemical plants response (Capra, 2014). Changes in the environmental conditions in response to the application of homeopathic preparations can redirect metabolic pathways with influence on the production of secondary metabolites, fresh and dry biomass production, yield and chemical composition of the essential oils in medicinal plants (Carvaho, 2004; Bonato, 2009; Andrade, 2012; Capra, 2014; Verdi, 2016).

Application of *Justicia Isotherapic* increased coumarin content on the leaves and stem of *Justicia pectoralis* Jacq. This result reaffirms that at the principle of similitude there is a response from the plants vital energy that canalize its energy for the production of secondary metabolites with pharmacologic activity (Andrade, 2012) such as antioxidant, antiasthmatic, (Cameron *et al.*, 2015; Moura *et al.*, 2017), anti-inflammatory (Nunes *et al.*, 2018).

In many cases it has only been reported that applications are made to the soil so that they reach the crops via absorption by the roots. However, it is striking that they are not applications for soil improvement

The application of homeopathic preparations on the soil and/or on the leaves can change the phytochemical profile of medicinal species (Castro, 2002b; Duarte, 2003; Armond *et al.*, 2005; Gonçalvez, 2010; Santos *et al.*, 2011; Andrade *et al.*, 2012; Capra *et al.*, 2014) and it can increase the essential oil yield (Almeida, 2002; Castro, 2002a; Duarte, 2003; Duarte, 2007; Bonato *et al.*, 2009; Verdi, 2016; Pereira *et al.*, 2019) (Figure 2). On the other hand, Carvalho *et al.* (2003) and Armond *et al.* (2003) observed a reduction in the production of secondary metabolites and no influence in the peroxidase and catalase enzymatic production when homeopathic preparation was applied on the species *Tanacetum parthenium* L. and *Bidens pilosa* L, respectively.

Homeopathic preparation affected the chromatographic profile of the essential oil of *Bidens pilosa* L. (Armond, 2005) showing distinctive peaks of organic acids like chlorogenic acid, acetylenes, flavonoids, which are bioactive molecules with antimalarial function. Therefore, the efficiency of the homeopathy to change the phytochemical spectrum, and to increase the yield of essential oils in plants used as medicine for humans health is of great social and economic importance.

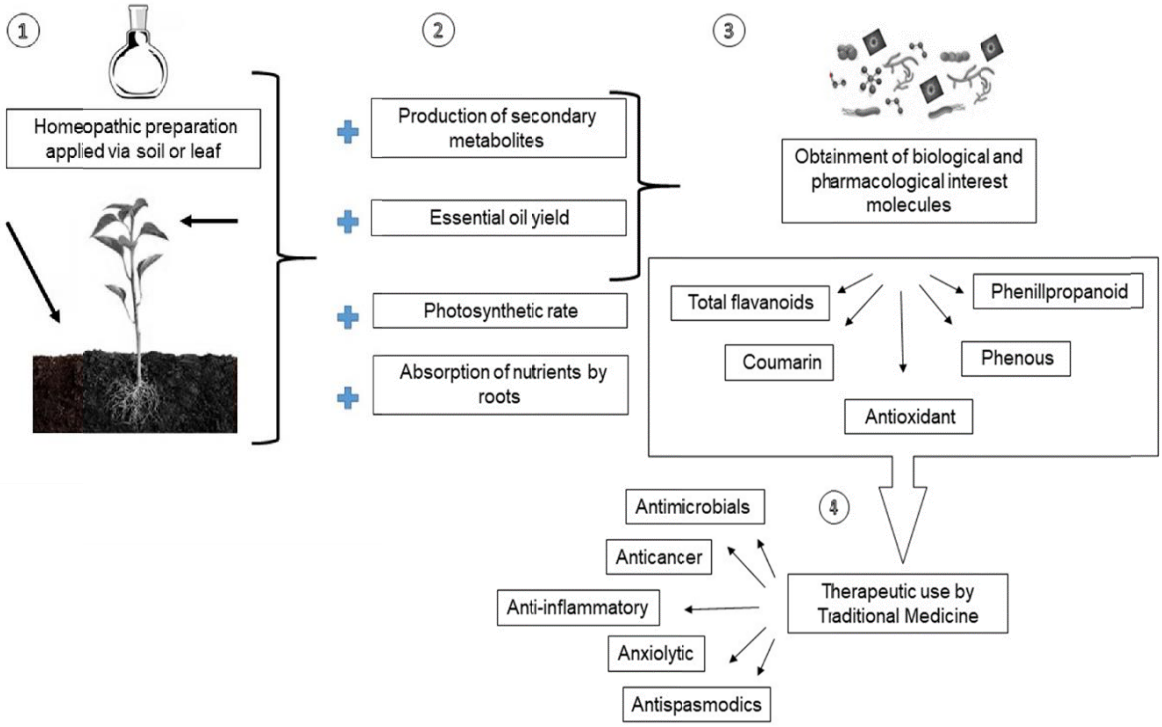


Figure 2: Benefits of the application of homeopathic preparations in the cultivation of plants. Suorce: Pereira *et al.*, 2019.

Figura 2: Beneficios de la aplicación de preparados homeopáticos en el cultivo de plantas. Fuente: Pereira *et al.*, 2019.

Ten out of seventeen studies on this work showed changes in the phytochemical profile of the medicinal plants as a function of homeopathic preparations. Castro (2002a) in applying *Sulphur* and *isotherapeutic* 12CH observed an alteration in the phytochemical profile of *Cymbopogon citratus* L. with an increase of neral and geraniol content. These compounds are used in the traditional medicine due to its antispasmodic and analgesics activity (Sadraei *et al.*, 2015).
According to Castro (2002b) and Duarte (2003) the application of homeopathic preparations—*Sulphur*, *Humic Acid 200CH* and *Ageratum conyzoides* L. *2CH*, *6CH*, *30CH*—in different dynamizations during the grown of *Justicia pectoralis* Jacq. and *Ageratum conyzoides* L. increased over 353% the coumarin content when compared to the control treatment. Evidences have shown that coumarin presents anti-inflammatory, antinociceptive, antispasmodics, muscle relaxant and anxiolytic properties, with great potential on the development of phytoterapics (Leal *et al.*, 2017).
The application of *Phosphorus* via soil in dynamizations (*3CH*, *12CH* and *30CH*) increased the levels of flavonoids responsible for antioxidant activity of the plants *Talinum triangulare* (Jacq.) Willd (Portulacaceae) (Gonçalvez, 2010; Liao *et al.*, 2015). *Phosphorus* in the dynamization 9 CH enhanced the production of beta-pineno acetatus, trans-pinocarveol, trans-pinocamphone and trans-pinocarvyl molecules in plants of *Verbena gratissima* therapeutically used due to its antimicrobial property (Santos *et al.*, 2011). Capra *et al.* (2014) verified an increase of 30% and 47% in the content of quercetin in response to the application of *Silicea terra 6cH, 7dH* and *Equisetum 7dH*, respectively, in the *Baccharis trimera* cultivation. This compound is widely employed in the treatment of liver diseases, diabetes and digestive disorders (Pádua *et al.*, 2010).
Despite it being evident that the soil can respond to homeopathic preparations, these evidences are not strong enough to conclude on the final result of these homeopathic treatments in the

improvement of the quality of the soil. Probably the time factor required to generate perceptible changes to the tools used is the element that requires further evaluation.

It is very important to consider that homeopathic treatment is applied to the soil for its uptake in the root system of the plant, and that it is not generally applied to the soil *per-se*. However, a treatment, of any kind, can affect or benefit the soil itself, by modifying its physical, chemical and also biological characteristics. The latter, because the applied treatment can beneficially or detrimentally modify the soil microbiota.

However, negative effects were also found by the researches Carvalho *et al.* (2003) and Carvalho *et al.* (2005). The use of *Arnica montana* in 5 dynamizations and and *Natrum muriaticum 2cH* in the cultivation of *Tanacetum parthenium* (L.) Schultz-Bip decreased the partenolidium content, an active principle that acts in carcinogenic cells.

4. Final Considerations

Homeopathic preparations applied via the soil for root intake or directly by spraying on the leafs during the cultivation of various plants, have changed or modified the phytochemical spectrum in treated crops. In general, it can be inferred that homeopathic medicines produced an increase in the production and yield of essential oils, and in the potential for the production of active principles with pharmacological and biological properties, as well as a greater tolerance to certain levels of salinization of the soils.

These essential oils and other active compounds have therapeutic uses as antioxidants, anticancer, antispasmodic and antimicrobial among other properties.

The research that addresses the use of homeopathy in the cultivation of plants, including medicinal plants, is of great relevance because it is a lifelong practice that aims not only to optimize agricultural production but also the quality of specific chemical components produced by medicinal plants. In addition to being an accessible practice to farmers, it contributes to the strengthening of agroecology and to the expansion of the production chain in an environmentally friendly way. To expand the benefits of agricultural homeopathy, more studies are needed to understand the influence of the application of the homeopathic medicines in the cultivation of various plants including vegetables, legumes and fruit trees and how it affects the production of secondary metabolites and essential oil, with potential nutritional or medical applications in human being and public health policies.

Finally, homeopathy in agriculture and applied to soils, seems to be a potential tool for recovering the balance and stability of soils, mainly when in synergy with other ecological techniques, intended to rescue the soil microbiota and consequently, the integral vitality of the agro-eco-system. However, more research is needed to better understand the mechanism of action and the process of restoring this balance.

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