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# Homoeopathic Approaches for Managing Major Pests of Tomato (*Solanum lycopersicum*) and Cucumber (*Cucumis sativus*): A Review of Current Evidence and Future Prospects

**Dr. G. Prema[1]*, Dr. Dushant Trigotra[2] , Dr.Rinku Bishwas[3]**

[1] BHMS., MD(Hom)., PhD scholar – Sri Ganganagar Homoeopathic Medical College and Hospital and Research Institute, Tantia University, Sri Ganganagar, Rajasthan.
[2] BHMS., MD(Hom)., PhD(Hom)., Guide, Associate Professor, Department of Repertory, Sri Ganganagar Homoeopathic Medical College and Hospital and Research Institute, Tantia University, Sri Ganganagar, Rajasthan.
[3]B .H.M.S., MD(Hom)., PhD(Hom)(Sc.), Professor & H.O.D., Department of Pathology & Microbiology, State Lalbahadur shastri Homoeopathic Medical College and Hospital ,Shantipuram,Prayagraj ,Uttar Pradesh

*Corresponding Author: Dr. G. Prema- BHMS., MD(Hom)., PhD scholar – Sri Ganganagar Homoeopathic Medical College and Hospital and Research Institute, Tantia University, Sri Ganganagar, Rajasthan.
E mail- drpremahomoeo@gmail.com

**Abstract**
The escalating reliance on synthetic chemical insecticides in conventional agriculture has induced severe ecological imbalances, accelerated pest resistance, and left hazardous chemical residues in food networks. These compounding crises necessitate non-toxic, sustainable, and cost-effective alternatives for crop protection. This review synthesizes current empirical evidence regarding the application of Agro-homeopathy, the use of ultra-high molecular dilutions of natural substances, as a viable strategy for managing major pest and pathogen complexes in tomato (*Solanum lycopersicum*) and cucumber (*Cucumis sativus*).
Data compiled from peer-reviewed field and laboratory trials demonstrate that potentized remedies operate through dual mechanisms: direct/repellent bio-toxicity and the upregulation of induced systemic resistance (ISR). In tomato crops, treatments such as *Sulphur 12CH* demonstrate an insect-suppressive efficacy against the small fruit borer complex equivalent to standard biological controls (*Bacillus thuringiensis*), while *Arnica montana 12CH* significantly optimizes macroscopic fruit yield. In cucumber systems, low-potency biochemics and centesimal dynamizations like *Arsenicum album 13CH* and *Silicea 7CH* remarkably enhance initial seed germination velocity, radicle development, and vegetative growth. Furthermore, remedies like *Cina 200CH* exhibit robust bio-pesticidal properties, driving a statistically significant reduction in highly destructive soil-borne root-knot nematodes (*Meloidogyne incognita*).
While Agro-homeopathy demonstrates immense potential for preserving beneficial natural predators and lowering input costs for smallholder organic farmers, field-scale adoption faces hurdles. These include a high coefficient of variation in open-field environments and a lack of universally standardized protocols regarding potency selection and application frequencies. This paper concludes that future research must prioritize multi-location, randomized complete block designs to standardize field deployment, positioning ultra-high dilutions as a core pillar of resilient organic agriculture.

**Keywords:** Agro-Homoeopathy; *Solanum lycopersicum*; *Cucumis sativus*; Ultra-high dilutions; Induced Systemic Resistance; Organic Pest Management.

## 1. Introduction:

The intensive cultivation of tomato (Solanum lycopersicum) and cucumber (Cucumis sativus) is severely threatened by destructive biotic stresses (Anamika et al., 2024; Rathour et al., 2025). In tomatoes, tissue-boring lepidopterans and leaf-feeding chrysomelids cause unmanaged crop losses of 40% to 70% (Modolon et al., 2012). Cucumbers are similarly constrained by sap-sucking insects (aphids, whiteflies, spider mites), root-knot nematodes (Meloidogyne incognita), and Fusarium rots, which lower thresholds for secondary infestations (Sukul et al., 2006).

To mitigate these losses, conventional agriculture relies on prophylactic, broad-spectrum synthetic pesticides and pyrethroids. However, because internal borers and root parasites feed deep within plant tissues, surface applications exhibit limited targeted efficiency. This forces farmers to increase dosages, accelerating toxic residue accumulation and environmental persistence (Ahamad & Kumar, 2023; Quiroz-González et al., 2024). Furthermore, these non-selective chemicals decimate beneficial predators like coccinellids and spiders, inducing pest resurgence, while escalating input costs deflate the net income of small and marginal farmers (Li et al., 2017).

Faced with chemical resistance, environmental degradation, and rising costs, transitioning to organic farming requires innovative, non-toxic alternatives like Agro-Homoeopathy—the application of ultra-high molecular dilutions manufactured through sequential dilution and succussion (Mazón-Suástegui et al., 2018). Instead of acting as direct toxins, these remedies function as biocompatible elicitors that upregulate secondary metabolites and trigger systemic acquired resistance (SAR) or induced systemic resistance (ISR). Being biodegradable and highly diluted, they leave zero residues, protect beneficial insects, and cost a fraction of synthetics (Prieto Méndez et al., 2021).

This review systematically evaluates the empirical evidence for using homeopathic remedies to manage pest, nematode, and pathogen complexes in tomato and cucumber crops, while critically analyzing their underlying mechanisms, operational challenges, and future prospects in large-scale sustainable agriculture.

## 2. Core Mechanisms of Agro-Homoeopathy in Crop Protection

Transitioning from conventional toxicology to Agro-Homoeopathy shifts the focus from dose-dependent toxico-dynamics to high-dilution pharmacology. Unlike traditional pesticides that require a critical biochemical concentration to disrupt a pest's nervous system, Agro-Homoeopathic remedies undergo decimal (D/DH/X) or centesimal (C/CH) potentization through serial dilution and succussion (vigorous shaking). This process often dilutes the solute past Avogadro's constant (>24X or >12C), leaving no raw molecular trace of the starting material. Despite this lack of physical molecules, empirical literature indicates these formulations protect crops through two distinct pathways: Direct/Repellent Bio-toxicity and Induced Systemic Resistance (ISR) (Sen et al., 2018). The flowchart in figure 1 illustrates how an Agro-Homoeopathic Remedy achieves Optimized Crop Protection through a dual-action mechanism divided into external and internal responses.

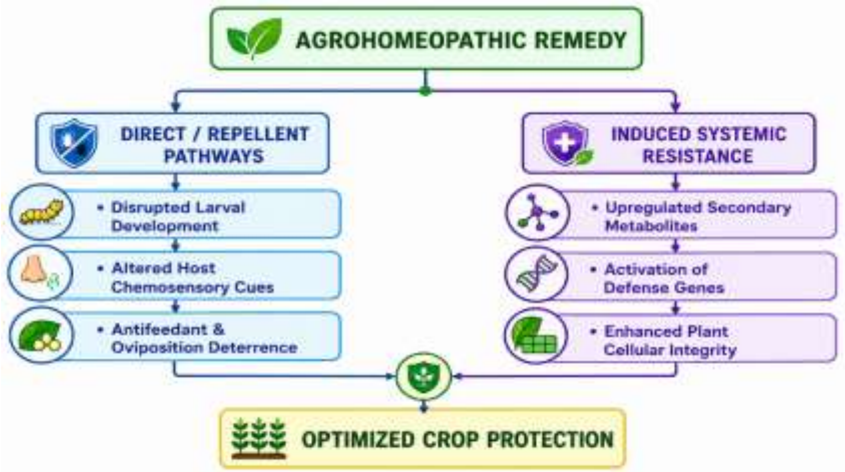


**Figure 1:** Proposed Direct and Induced Resistance Mechanisms Underlying Agro-Homoeopathic Efficacy

## 3. Evidence on Tomato (*Solanum lycopersicum*) Management

The empirical validation of Agro-Homoeopathy within the Solanaceae family demonstrates a measurable capacity to suppress pest populations, mitigate pathogen vectors, and enhance crop yield parameters under organic management regimes. Because tomatoes suffer from an overlapping complex of chewing, boring, and sucking pests similar to other nightshades, the literature evaluates both tomato-specific field trials and highly transferable protocols established on closely related Solanaceae crops like the eggplant (Solanum melongena).

As conceptualized in figure 2, tomato crop degradation is driven by a destructive multi-trophic synergy: insect feeding creates entry wounds for opportunistic fungi, while the resulting fungal stress attracts secondary pest complexes. Integrating targeted Agro-Homoeopathic remedies breaks this feedback loop, protecting the crop through the specific field-tested interventions detailed in Table 1 (Kaviraj, 2015; Khanna & Chandra, 1992; Shinde et al., 2020).

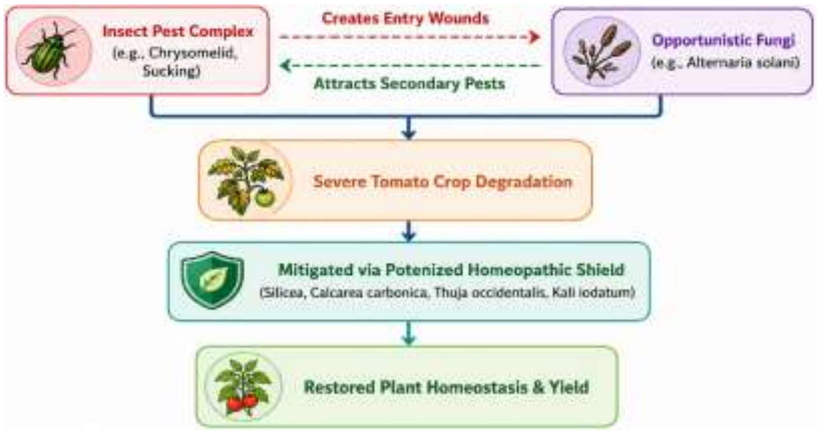


**Figure 2:** Homeopathic Shield: Mitigating Pest-Fungi interactions and Restoring Tomato Crop Health

**Table 1: Agro-Homoeopathic Interventions for Solanaceae Crop Protection**

| Remedy & Potency | Target Pest / Pathogen | System & Application | Key Mechanism & Efficacy Outcomes |
|---|---|---|---|
| ***Sulphur* 12CH** | Small tomato fruit borer complex *(Helicoverpa armigera)* | Tomato; Open field trial | Reduced small fruit borer damage equivalently to the biological insecticide *Bacillus thuringiensis*. Efficacy varied against larger *H. armigera* strains, showing species-specificity. |
| ***Arnica montana* 12DH** | Tissue trauma from chewing pests | Tomato; Foliar spray | Functions as an agronomic restorative that limits tissue trauma from pest feeding, maximizing total yield parameters during peak fruit-bearing periods. |
| ***Thuja occidentalis* 200CH** | Shoot and fruit borer *(Leucinodes orbonalis)* | Nightshades; Systematic foliar | Systematically alters the plant's inner biochemical profile to induce an absolute antifeedant response, forcing larvae out of internal tissue borings where they face open-air predators. |
| ***Cantharis* 6x** | Hadda beetle *(Henosepilachna vigintioctopunctata)* | Tomato & Eggplant; Field trial | Served as a viable, residue-free alternative to hazardous synthetic pyrethroids (Cypermethrin), successfully suppressing adult and larval foliage-skeletonizing damage. |
| ***Silicea*, *Calcarea carbonica*, & *Mercurius solubilis*** | Early blight *(Alternaria solani)* & Vascular wilts *(Fusarium oxysporum)* | Tomato; Plant shield mechanism | Preserves the physical integrity of the tomato cuticle and strengthens cell walls by directly inhibiting mycelial growth and pathogen spore germination. |
| ***Kali iodatum* 149CH & *Thuja occidentalis* 87CH** | Fruit rot *(Fusarium roseum)* | Tomato; Post-harvest application | Minimizes post-harvest fruit rot by directly altering fungal respiration rates and spore germination without dropping toxic residues into food networks. |

**4. Evidence on Cucumber (Cucumis sativus) Management**

While Agro-Homoeopathic research for nightshades predominantly focuses on managing macroscopic chewing and boring pests, empirical studies on cucurbits—specifically the cucumber (Cucumis sativus)—take a distinct approach. Research highlights cellular protection, subterranean parasite suppression, and the optimization of metabolic signalling under organic cultivation regimes (Dudchenko et al., 2025). Cucumbers are exceptionally sensitive to ambient environmental changes and oxidative stresses caused by sap-sucking pests (such as aphids, whiteflies, and spider mites) and associated viral or fungal vectors (Abasolo-Pacheco et al., 2020). The application of ultra-high dilutions in cucumber management provides a unique window into how homeopathic remedies modulate physiological defence mechanisms and genetic expression to preserve crop health.

As conceptualized in the experimental layout of figure 3 (and the specific bio-chemic grouping), early treatment with low-potency mineral remedies fundamentally reshapes early seedling development and long-term crop vitality without requiring synthetic chemical fertilizers (Praveen Raj & Maria Dhivya, 2021).

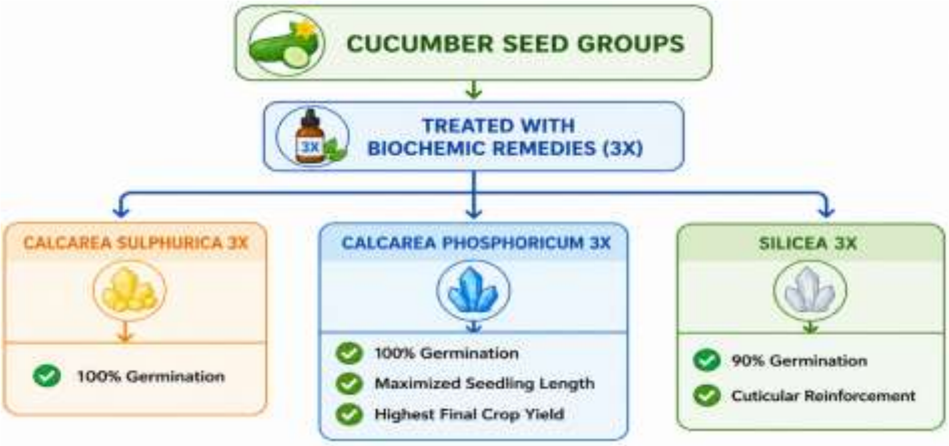


**Figure 3:** Reported Effects of Selected Biochemic Remedies (3X) on Cucumber Seed Germination, Seedling Growth, and Yield Parameters

These low-potency dynamics, alongside higher dynamizations used for pest, parasite, and chemical stress mitigation, are systematically summarized in Table 2.

**Table 2: Agro-Homoeopathic Interventions for Cucumber Crop Protection and Restoration**

| Remedy & Potency | Target Stress / Parasite Complex | Application Method | Key Mechanism & Efficacy Outcomes |
|---|---|---|---|
| ***Calcarea phosphoricum* 3X & *Calcarea sulphurica* 3X** | Poor seed germination & vegetative stunting | Seed treatment via uniform irrigation water | Achieved a perfect 100% seed germination rate compared to 70% in untreated controls. *Calcarea phosphorica* 3X exerted the most prominent positive impact on vegetative growth length (at Day 25) and generated the highest final crop yield by stimulating core nitrogen-calcium-phosphorus absorption mechanisms (Praveen Raj & Maria Dhivya (2021). |
| ***Silicea* 3X** | Weak structural integrity & physical vulnerability | Seed treatment via uniform irrigation water | Achieved a 90% seed germination rate and induced clear cuticular reinforcement, establishing early mechanical and structural defence barriers in the developing seedlings (Praveen Raj & Maria Dhivya (2021). |
| **Targeted Homeopathic Elicitors** | Sap-sucking pests (aphids, whiteflies, spider mites) & oxidative stress | Foliar spray or root drench systems | Triggers cellular signaling cascades that rapidly synthesize protective enzymes, upregulating catalase (CAT) and guaiacol peroxidase (GPX). These enzymes scavenge reactive oxygen species (ROS) from pest feeding, preventing premature leaf yellowing and localized necrosis while optimizing chlorophyll retention, stomatal conductance, and photosynthetic rates under pest pressure Mazón-Suástegui et al. (2018). |
| ***Cina* 200CH** | Root-knot nematodes *(Meloidogyne incognita)* | Soil matrix/seed administration | Induced a profound biocontrol outcome with a statistically significant reduction ($p < 0.01$) in root gall numbers and a massive drop in total rhizosphere nematode populations. Treated groups retained significantly higher leaf surface areas and chlorophyll indices, shielding the crop's vascular framework Sukul et al. (2006). |
| ***Nux vomica*, *Carbo vegetabilis*, & *Arsenicum*** | Auxinic herbicide toxicity (2,4-D | Controlled BOD germination chamber setups | Evaluated under the Principle of Similarity (*Similia Similibus Curentur*). *Nux vomica* (6CH through 30CH) acted directly on the vigor of poisoned seedlings, reversing cell callosity, reducing abnormal root |

| | | | |
|---|---|---|---|
| ***album* (6CH to 30CH)** | and picloram residues) | | thickening, restoring seedling height, and clearing chemical blockages to restore metabolic homeostasis (Canadian Society for Organic Urban Land Care, 2017). |

**5. Statistical Validation and Quantitative Trends**

The experimental studies included in this review predominantly employed standard agricultural biometrical methods to evaluate the effects of Agro-Homoeopathic treatments. Laboratory investigations commonly adopted Completely Randomized Designs (CRD), whereas field experiments generally used Randomized Complete Block Designs (RCBD) to minimize environmental variability associated with soil heterogeneity and field conditions. Treatment effects were typically evaluated using analysis of variance (ANOVA), followed by post-hoc multiple comparison procedures such as Tukey's Honestly Significant Difference (HSD) test or Duncan's Multiple Range Test (DMRT), with statistical significance accepted at $P < 0.05$ or $P < 0.01$ (Patel et al., 2001; Sawyer, 2009).

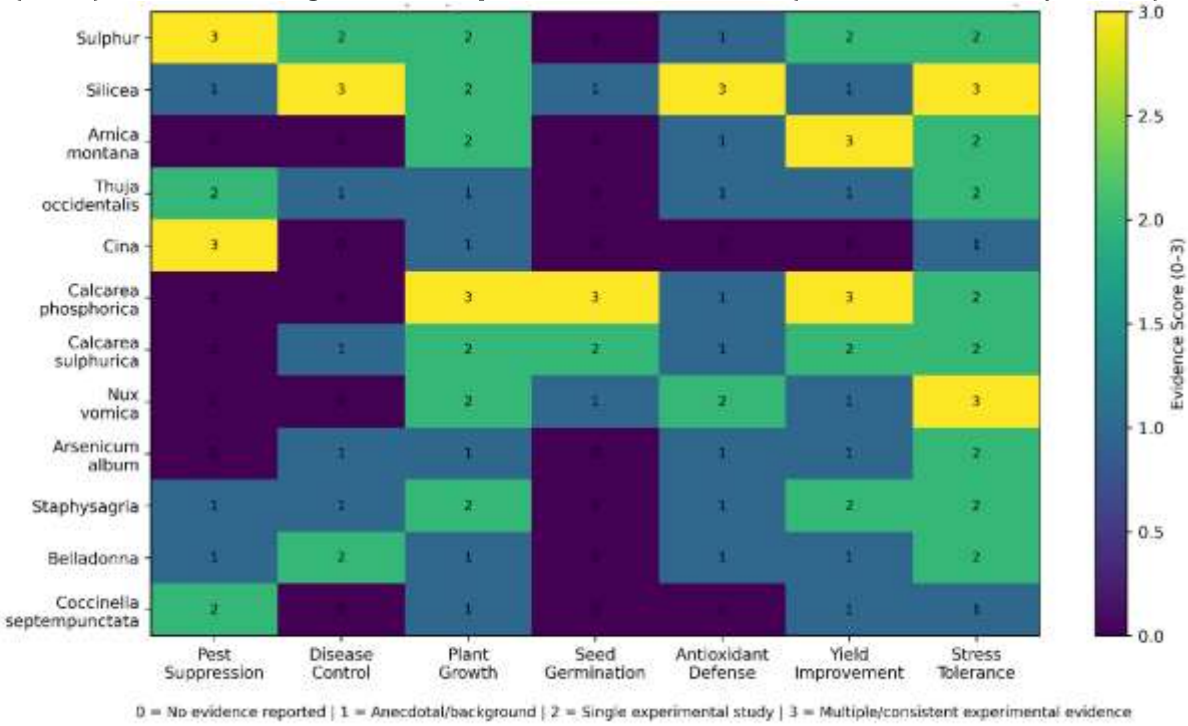


**Figure 4:** Heat Map of Reported Biological Effects of Agro-Homoeopathic Remedies in Tomato (Solanum lycopersicum) and Cucumber (Cucumis sativus) Crops

Across the reviewed studies, statistically significant improvements were reported for several agronomic and plant health parameters. In cucumber, treatment with Calcarea phosphorica 3X and Calcarea sulphurica 3X increased seed germination from 70% in the untreated control to 100%, representing an absolute improvement of 30 percentage points (approximately 43% relative increase), with differences confirmed by Tukey's HSD ($P < 0.05$). Likewise, enhanced seedling growth and crop performance were reported following biochemic treatments (Praveen Raj & Maria Dhivya, 2021).

In organically managed tomato, Modolon et al. (2012) observed that Sulphur 12CH significantly reduced damage caused by the small tomato fruit borer, with pest suppression comparable to that achieved using Bacillus thuringiensis. The same study also reported significantly greater fruit yield in plants treated with Arnica montana 12CH compared with untreated controls, indicating that certain homeopathic preparations may improve crop performance under field conditions.

Other experimental studies demonstrated significant reductions in disease severity, inhibition of fungal growth, improvements in antioxidant enzyme activity, and suppression of root-knot nematode infestation following selected Agro-Homoeopathic treatments. However, these responses varied considerably among remedies, potencies, crops, and experimental conditions, indicating that treatment effects are not universally reproducible across all systems.

The distribution of evidence across remedies and biological outcomes is summarized in Figure 4, which highlights that Sulphur, Silicea, Arnica

montana, and Calcarea phosphorica have received comparatively greater experimental attention than most other remedies.
Overall, the available evidence suggests that several Agro-Homoeopathic interventions have produced statistically significant biological responses under controlled experimental conditions. Nevertheless, most studies involved relatively small sample sizes, single-location trials, or limited growing seasons. Consequently, larger multi-location experiments employing standardized protocols and rigorous statistical analyses are required before definitive conclusions regarding efficacy and practical agricultural applications can be drawn.

## 6. Discussion

The studies reviewed collectively indicate that Agro-Homoeopathy has the potential to contribute to sustainable crop protection by improving plant vigor, reducing pest damage, and enhancing resistance to both biotic and abiotic stresses. Unlike conventional pesticides, which primarily act through direct toxicity to target organisms, Homeopathic preparations have been reported to influence plant physiological processes, potentially strengthening the plant's inherent defence capacity. This distinction is evident across studies conducted on tomato, cucumber, bean, and other horticultural crops, where improvements in growth, yield, disease resistance, and pest suppression were observed following the application of potentized preparations.
Among the available evidence, the field experiments conducted by Modolon et al. (2012) provide one of the strongest demonstrations of Agro-Homoeopathy under practical farming conditions. Sulphur 12CH reduced damage caused by the small tomato fruit borer to a level comparable with the biological insecticide Bacillus thuringiensis, while Arnica montana 12DH significantly increased tomato yield. Likewise, potentized Solanum lycopersicum preparations effectively suppressed Septoria leaf spot under greenhouse conditions (Kaviraj, 2015). These findings suggest that homeopathic preparations can simultaneously contribute to pest management and crop productivity within organic production systems.
Evidence from cucumber research indicates that Agro-Homoeopathy may provide benefits through mechanisms that differ from direct insecticidal activity. Low-potency mineral remedies such as Calcarea phosphorica, Calcarea sulphurica, and Silicea improved seed germination, seedling growth, and overall plant vigor, whereas Cina 200CH significantly reduced root-knot nematode (Meloidogyne incognita) infestation (Mazón-Suástegui et al., 2018). Similarly, the application of Carbo vegetabilis and Silicea terra enhanced water-retaining capacity and improved plant performance under water-limited conditions, suggesting that increased stress tolerance may indirectly improve resistance to pest attack (Canadian Society for Organic Urban Land Care, 2017). These findings support the concept that healthier plants are generally better able to withstand pest pressure and recover from damage.
Recent evidence further strengthens the potential role of Agro-Homoeopathy in integrated pest management. Quiroz-González et al. (2024) demonstrated that foliar application of a 200CH nosode in common bean increased yield by more than 100%, enhanced biomass, root development, pod production, membrane stability, and phenolic compound accumulation, while reducing pod damage and achieving up to 80% mortality of the storage pest Zabrotes subfasciatus. Increased phenolic content is particularly noteworthy because phenolic compounds are well-recognized components of plant defence systems and may contribute to enhanced resistance against insect pests and pathogens. However, the same study also reported that conventional pest management remained more effective against the field pest Diabrotica balteata, indicating that Agro-Homoeopathy may not provide uniform control across all pest species.
The reviewed literature also highlights considerable variability in treatment responses. The effectiveness of homeopathic preparations appears to depend on several interacting factors, including crop species, target pest or pathogen, remedy selection, potency, application timing, environmental conditions, and experimental design. For example, Sulphur 12CH effectively controlled the small tomato fruit borer but did not significantly reduce larger borer infestations, illustrating that efficacy is often species-specific rather than universal (Khanna & Chandra, 1992). Similarly, some fungal studies have reported growth inhibition with certain remedies and potencies (Abasolo-Pacheco et al., 2020), whereas others observed neutral or even stimulatory effects on pathogen development (Suya et al., 2023). Such variability emphasizes that Agro-Homoeopathy cannot yet be considered a universally applicable replacement for conventional pest management.
Another important observation emerging from the reviewed studies is that most positive results involve improvements in plant physiological status rather than direct pesticidal action. Enhanced membrane stability, increased antioxidant enzyme activity, greater phenolic accumulation, improved nutrient uptake, stronger root systems, and higher photosynthetic efficiency collectively suggest that homeopathic preparations may function as elicitors of induced resistance rather than conventional toxic agents (Oliveira et al., 2014). This interpretation is

consistent with the concepts of induced systemic resistance (ISR) and systemic acquired resistance (SAR), where plants activate endogenous defence pathways following exposure to appropriate stimuli. Nevertheless, the precise molecular and biochemical mechanisms underlying these responses remain insufficiently understood and require further investigation.

Despite encouraging findings, the current evidence base has several limitations. Many studies have been conducted under greenhouse or laboratory conditions with relatively small sample sizes, while comparatively few large-scale, multi-location field trials have been published. Experimental protocols also vary substantially with respect to potency selection, preparation methods, application frequency, environmental conditions, and outcome measurements, making direct comparison between studies difficult. Furthermore, many publications report positive findings without detailed mechanistic investigations or long-term validation under diverse agroecological conditions.

Future research should therefore prioritize well-designed randomized complete block experiments conducted across multiple growing seasons and geographic regions. Standardized protocols for remedy preparation, potency selection, application intervals, and statistical analysis would substantially improve reproducibility and facilitate meta-analyses. Integrating physiological, biochemical, transcriptomic, metabolomic, and microbiome analyses may also help elucidate the biological mechanisms underlying reported effects. Such multidisciplinary approaches are essential for determining whether Agro-Homoeopathy can be reliably incorporated into integrated pest management programs alongside biological control, resistant cultivars, and other sustainable agricultural practices.

## 7. Conclusion

The growing challenges of chemical pest resistance, environmental contamination, and increasing production costs highlight the need for sustainable alternatives to conventional pesticide-based crop protection. This review indicates that Agro-Homoeopathy shows promise as an environmentally friendly approach for managing pests and improving crop performance in tomato (Solanum lycopersicum) and cucumber (Cucumis sativus). Evidence from laboratory, greenhouse, and field studies suggests that homeopathic preparations can reduce damage caused by selected insect pests, nematodes, and pathogens while simultaneously enhancing plant growth, yield, and physiological resilience. The reported effects are thought to involve both direct influences on target organisms and the activation of plant defence mechanisms, including increased antioxidant activity and the induction of defence-related pathways such as phenylalanine ammonia-lyase (PAL), peroxidase (POX), and polyphenol oxidase (PPO).

Despite these encouraging findings, the current evidence remains heterogeneous, with treatment responses varying according to crop species, target pest, remedy, potency, application schedule, and environmental conditions. Consequently, Agro-Homoeopathy should presently be regarded as a complementary component of integrated pest management rather than a complete replacement for conventional or biological control strategies. Future research should focus on well-designed, multi-location randomized complete block design (RCBD) field trials, standardized preparation and application protocols, and mechanistic investigations integrating physiological, biochemical, and molecular approaches. Such studies will be essential to establish reproducible recommendations and to determine the role of Agro-Homoeopathy in resilient, sustainable, and low-input agricultural systems.

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