

Beyond Biological Control: An Integrated Mineral Intervention Strategy Against *Thrips parvispinus* in Greenhouse Pepper

A deployment-oriented technical framework combining KNAMAX™ activated alkaline water and ACARISIN™ mineral contact protection, with stage-specific engineering, predictive efficacy thresholds, and cost-in-use modelling

José M. López, R+D+I Director

Critical technical synthesis, intervention design and industrial economic analysis

Abstract

The rapid expansion of *Thrips parvispinus* in protected pepper production in southeastern Spain has exposed a structural vulnerability in biological-control programmes optimised for flower-dwelling thrips. A 2026 semi-field study found that only 5.5% of *T. parvispinus* occupied flowers, while the most effective tested predator, *Orius laevigatus*, did not eliminate the challenge. The pest also protects its eggs within plant tissue and commonly undergoes pupation in the substrate. These features call for a spatially and temporally distributed intervention rather than a single foliar or predator-focused response. This article develops a practical, cost-oriented intervention architecture based on two existing proprietary mineral technology platforms: KNAMAX™ water-conditioning technology, producing activated alkaline ionised water (AAI), and ACARISIN™, a food-grade mineral system with documented historical pest-protection applications. The core proposition is not that generic mineral ingredients necessarily kill this species: it is that a staged deployment of an aqueous intervention module, mineral contact protection, focal substrate management, exclusion and surveillance can reduce the effective reproductive multiplier by acting on different life-history compartments. Operating windows, analytical safeguards, a repeatable 21-day programme, dose-calculation examples and transparent €/ha scenarios are specified. Crucially, company-specific historical efficacy is distinguished from species-specific predicted outcomes. The paper defines measurable success thresholds without presenting forecast reductions as observed trial results and identifies the exact regulatory distinction between food-grade ingredients, approved basic substances and authorisation of a commercial product for a particular insect-control use.

Keywords: *Thrips parvispinus*; sweet pepper; *Capsicum annuum*; integrated pest management; AAI; KNAMAX; ACARISIN; mineral contact protection; greenhouse economics; pest population dynamics.

Technical propositions

- The pest-management unit must be the complete generation and not just the number of adults killed immediately after a spray.
- Canopy deposition should primarily target young leaves and concealed leaf surfaces rather than be designed around flowers alone.

- KNAMAX™ and ACARISIN™ should be sequentially engineered, although both can be used in combination.
- The operating dose should be calculated on individual basis and infestation situation.
- Predicted costs can be materially below reported exceptional biological-control outlays, but the comparison requires equivalent time horizons and inclusion of all cultivation-side costs.

1. From an exceptional farm crisis to an actionable engineering problem

A report published on 19 October 2026 described extensive anxiety among pepper growers in Almería, citing statements that approximately 60% of farms were affected, 200 ha had already been uprooted and some growers had spent more than €20,000/ha on biological control without achieving adequate suppression [1]. These are attributed stakeholder reports rather than a statistically sampled, auditable cost-of-control dataset. They nevertheless provide a clear industrial signal: growers require faster detection, more effective interception of successive cohorts and lower marginal treatment costs.

The relevant scientific question is not whether biological control works in principle. In a pepper-specific greenhouse experiment, Rodríguez and colleagues found that Orius laevigatus gave the strongest suppression among the tested predators, alone or as part of a three-predator combination, and better yields than less effective approaches [2]. Yet the pest occurred predominantly on leaves; only 5.5% of individuals were observed in flowers. This is a major departure from established control practice developed around Frankliniella occidentalis. It supports a change in delivery geometry, scouting allocation and intervention timing. The practical implication is to complement -rather than indiscriminately remove- effective natural enemies with treatments operating in otherwise poorly covered compartments.

2. Target organism and intervention geometry

Thrips parvispinus is a minute thysanopteran with a damaging feeding apparatus and a pronounced capacity for rapid population growth at greenhouse temperatures. Adult females place eggs within leaf tissue. Two feeding larval instars are typically followed by a non-feeding prepupal stage and a pupal stage, frequently in or near the substrate. Adult survival and generation time respond strongly to temperature and host-plant condition [3]. A recent review reports development of approximately 14 days at around 25.6 °C, with pupation typically in soil at an approximate depth of 2.5 cm in the cited experiments [3]. The precise dynamics in an Almería greenhouse will vary with temperature, crop architecture and microhabitat.

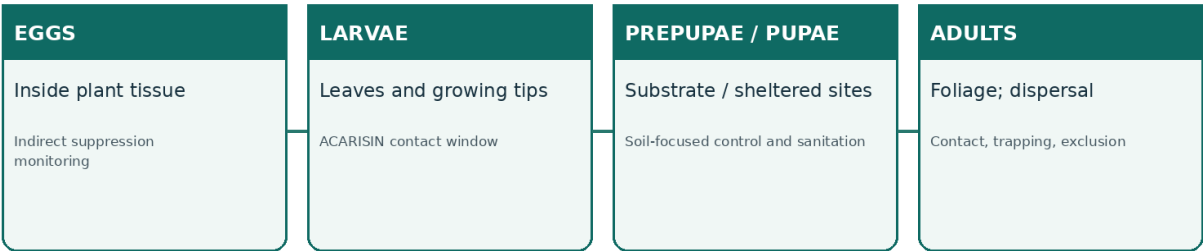


Figure 1. The relevant pest compartments and the corresponding proposed intervention targets. Schematic; not a claim of stage-specific observed mortality with KNAMAX™ or ACARISIN™.

2.1 Eggs: the inaccessible reserve

Eggs inserted into plant tissue constitute a delayed cohort protected from many contact treatments. A product performing impressively against exposed larvae cannot be assumed to be ovicidal against embedded eggs. The intervention design must therefore schedule observation and follow-up around the expected emergence of new larvae rather than mistake an immediate decline in adults for eradication.

2.2 Feeding larvae: the contact opportunity

Larvae in growing tips and on leaf undersides present an accessible contact window, provided the material actually reaches their microhabitat. In practice, droplet density, canopy penetration, wetting, leaf angle, deposits after drying and the ability to avoid drift onto biological-control organisms are at least as important as the nominal concentration in the tank. Targeting leaves is more defensible for this species than relying only on a flower-oriented sampling or delivery strategy [2].

2.3 Prepupae and pupae: the substrate reserve

Pupation associated with the substrate creates a source of adults that survives a purely foliar intervention. The Andalusian resolution of 10 April 2026 specifically requires sanitation and, in affected areas undergoing crop removal, certain authorised diatomaceous-earth-based soil treatments; it also recommends solarisation or biosolarisation where practicable [4]. Those requirements cannot be replaced by assuming that all mineral powders are legally or technically interchangeable. However, their entomological rationale is directly relevant to a modular system targeting emergence from soil.

2.4 Adults: dispersal and reintroduction

Adults colonise adjacent crop zones, survive in sheltered habitats and can rapidly rebuild populations. Crop exclusion, perimeter trapping, careful plant movement, neighbouring farm coordination and continuous scouting are therefore non-optional complements to any contact intervention. A treatment can succeed against the existing population yet fail commercially because recolonisation exceeds suppression.

3. Existing industrial platforms: evidentiary strength and transfer limits

3.1 ACARISIN™: historical mineral pest-control experience

ACARISIN™ is presented in manufacturer technical literature as a proprietary processed food-grade mineral platform with applications in stored materials and protection against insects, mites and developmental stages. The current product sheet identifies food-grade components and the manufacturer's Single Grain Fusion Technology™ [5]. Internal evidence registers compile tests involving stored-product pests, mites and phytopathogens, as well as operational field reports [6]. The strongest independent product-specific academic record traced in the file concerns inhibition of *Botrytis cinerea* in vitro under defined experimental conditions. That work documents biological activity in its own domain but is not a direct thrips trial. Likewise, high mortality in stored-grain insects cannot be converted into the same percentage for leaf-dwelling *T. parvispinus*: the host environment, humidity, substrate, exposure duration, life stage and formulation differ.

The existing ECO-EFF™ + STERILFOOD K™ dossier describes a combined intervention against *Tagosodes* in rice, with ECO-EFF™ prepared in an aqueous suspension at 20 g/L [7]. That is an important process precedent for mineral suspension handling, nozzle suitability and repeated deployment. Because the historical outcome is attributed to a combined programme, it cannot establish the standalone efficacy of ACARISIN™ or ECO-EFF™ against *T. parvispinus*. Nor is 20 g/L a universally appropriate or crop-safe pepper concentration.

3.2 KNAMAX™: a conditioned process-water technology

KNAMAX™ is an established proprietary mineral water-conditioning technology used to prepare AAI for specific industrial purposes. The manufacturer's records define operating concentrations in relation to source-water chemistry and describe control of pH, conductivity, temperature, treatment contact and water renewal [8]. This article deliberately does not disclose proprietary composition, manufacturing ratios or critical industrial parameters.

For greenhouse pest management, two distinct deployment contexts must not be conflated. The first is unoccupied-infrastructure water conditioning and sanitation, where material compatibility, occupational exposure and applicable

legal use have to be addressed. The second is exposure of living crop foliage to an aqueous preparation, where tissue chemistry, root-zone contamination and beneficial arthropod exposure create wholly different constraints. A high-alkalinity process-water formulation cannot be declared phytosafe merely because its inputs have a food-grade specification. The useful optimisation variable is the measured state of the delivered water, not an unexamined percentage of concentrate.

3.3 Mechanistic interpretation without unsupported shortcuts

Mineral contact protection may depend on physical deposition, cuticle interaction, desiccation, local osmotic conditions, wetting and access to vulnerable cuticular or spiracular interfaces. Which of those processes dominates depends on the formulation and target arthropod. Aqueous alkaline exposures can also affect surface chemistry, but neither antimicrobial experience nor altered conductivity proves insect electroporation. Classical electroporation involves a sufficiently intense electric field and measurable membrane permeabilisation; it should not be used as a mechanistic label without specific evidence. A precise industrial claim should therefore focus on observable endpoints -mortality, feeding inhibition, reduced emergence, deposit persistence and host-plant compatibility- while using mechanism as a testable explanatory model.

4. The dual-platform proposition: immediate contact and protected-state pressure

The most defensible engineering architecture uses complementary operations rather than an unverified tank mixture. KNAMAX™ provides a controllable water-conditioning and sanitation module for designated settings and, if a plant-compatible preparation is established, a candidate short-contact foliar function. ACARISIN™ provides the mineral-contact module directed at exposed leaf-stage populations or other authorised sites. Perimeter exclusion and substrate sanitation act on introduction and emergence. By distributing control in space and time, the programme is designed to reduce the number of viable females reaching the next reproductive cycle.

Module	Principal target	Controllable variable	Primary performance metric
AAI water conditioning / structures	Reservoirs, cleared surfaces	Final pH, alkalinity, conductivity, exposure	Recoverable insects / contamination indicators
ACARISIN™ foliar contact	Exposed feeding larvae and adults	Concentration, delivered dose, leaf coverage	Live larvae/leaf; live adults/leaf
Substrate and exclusion	Pupae, adult emergence, recolonisation	Soil state, traps, crop hygiene	Emergence traps; immigration index
Surveillance and decisions	All compartments over time	Sampling frequency, trigger thresholds	Population trend and marketable yield

5. Dose and process engineering

5.1 Quantifying the ACARISIN™ suspension

A technically useful starting matrix is a staged suspension study at 2, 5 and 10 g/L, with a higher 20 g/L arm restricted to an adequately controlled setting where host-tissue safety and product physical properties have been established. The range is chosen to span concentrations materially below the 20 g/L historical ECO-EFF™ suspension precedent and should not be misrepresented as an established or approved T. parvispinus label. The values below calculate the amount needed to charge a spray tank; they do not demonstrate an efficacious delivered dose.

Nominal suspension	500 L/ha spray volume	750 L/ha spray volume	Interpretation
2 g/L (0.2% w/v)	1.0 kg/ha	1.5 kg/ha	Lower contact-deposit screening level
5 g/L (0.5% w/v)	2.5 kg/ha	3.75 kg/ha	Principal technical assessment arm
10 g/L (1.0% w/v)	5.0 kg/ha	7.5 kg/ha	High-deposit assessment arm
20 g/L (2.0% w/v)	10.0 kg/ha	15.0 kg/ha	Historical formulation reference; not a pepper recommendation

The governing material balance is $M_A \text{ (kg/ha)} = C_A \text{ (g/L)} \times V \text{ (L/ha)} / 1,000$. For example, 5 g/L at 600 L/ha requires 3.0 kg/ha. True deposit should additionally be expressed as mg/cm^2 on the upper and lower leaf surface. A programme controlling only the tank concentration but not the leaf deposit will have poor inter-farm reproducibility.

5.2 AAI process envelope for plant-adjacent operations

For KNAMAX™ the relevant dosage cannot responsibly be inferred from historical food-processing applications. Instead, prepare process water under a product-specific operating procedure, determine its final pH, titratable alkalinity, conductivity and temperature, and investigate whether it has a foliar-compatible window. As a development gate, leaf-safety screening may assess near-neutral and mildly alkaline preparations, with more alkaline conditions confined to non-crop laboratory tests unless leaf tolerance is proven. This does not imply that lowering the pH preserves a desired AAI mechanism; it may not. If a demonstrably functional AAI preparation cannot be made crop-compatible, reserve KNAMAX™ for compliant non-foliar uses. That is a design decision, not an abandonment of the combined platform.

A high-pH aerosol and a food-grade ingredient can still present occupational and material compatibility hazards. Nozzle corrosion, surface damage, worker eye exposure, mixing with acids or oxidants and root-zone chemical loading must be controlled under the relevant safety data and approved use conditions. KNAMAX™ and ACARISIN™ should be evaluated as separate sequential operations before any compatibility claim is made.

5.3 Crop architecture and deposit verification

On each representative crop, use water-sensitive cards or an equivalent deposition technique at the leaf underside, shoot centre and lower canopy; inspect nozzle and filter fouling after mixing and recirculation; record ambient humidity, drying time and the persistence of deposits after a representative wetting event. The system should aim for coverage of occupied microhabitats without creating unnecessary runoff. Increasing spray volume without checking deposition may increase labour, water and crop burden without increasing insect exposure.

6. A practical 21-day intervention architecture

The following is a staged implementation framework for a site holding the appropriate rights and permissions for each crop-protection use. Intervals must be reconciled with the applicable product label, useful-predator release schedule, greenhouse conditions and pest generation time. Its purpose is to specify operational decisions rather than promise that a fixed calendar eliminates the infestation.

Timing	Priority action	Evidence or trigger	Measurement
Pre-cycle / cleared greenhouse	Remove crop residues; structure hygiene; KNAMAX™ on eligible cleared surfaces; protect perimeter; manage substrate	Empty-site access; known hotspots	Trap captures, protected-site hygiene, soil status

Day 0	Map hot spots; ACARISIN™ stage-targeted contact treatment only if authorised; retain beneficial programme	Baseline larvae + adults per sampled leaf	Leaf counts; deposition; phytotoxicity
Day 3–5	Detect surviving larvae and emergence from embedded eggs; respond to validated threshold	Larval rebound and spatial clustering	Live larvae and predators; crop quality
Day 7–10	Reassess whole-canopy and soil emergence; carry out compatible follow-up as warranted	Generation progression and emergence	Larvae; adult flight; emergence cups
Day 14–16	Focus on the second cohort and immigration sources	New adult captures; trend versus baseline	Density ratios; marketable-fruit damage
Day 21	Decide maintain / intensify / discontinue / remove damaged crop	Effective growth multiplier and crop value	Cumulative costs; recovered output

The sampling programme should combine consistent leaf counts from standard upper, middle and lower canopy positions, sticky-trap catches for flight activity and substrate-emergence traps where feasible. Flowers should still be sampled to detect altered behaviour and local population shifts; however, an exclusively flower-based metric would undercount the principal infestation [2].

7. Predictive dynamics: what level of suppression would actually be sufficient?

A stage-targeted programme must be judged over the full generation. Let R_0 denote the per-generation multiplication factor in the absence of intervention and let S denote the total proportional reduction in successful reproduction and recruitment through all interventions. A first-order expression is $R_{\text{eff}} = R_0 (1 - S)$. Population decline requires $R_{\text{eff}} < 1$. This is a sensitivity model—not a fitted reproductive parameter for an Almería greenhouse.

Untreated multiplication per generation (illustrative)	Minimum integrated suppression for decline
2.0×	>50.0%
3.0×	>66.7%
4.0×	>75.0%
5.0×	>80.0%
6.0×	>83.3%

Suppression is not the arithmetic sum of separate treatment mortalities unless exposures are independent and cover the same defined cohort. A more informative factorisation is $R_{\text{eff}} = R_0 \times s_e \times s_l \times s_p \times s_a \times m$, where each s term denotes effective survival or recruitment in a stage and m represents an immigration/recolonisation multiplier defined against the reference. Estimation should be performed from treatment cohorts and field observations; inserting guessed stage mortalities gives a planning scenario, not evidence. The practical implication is that intervention on larvae plus pupal emergence may outperform another adult-only intervention even when immediate adult kill appears less spectacular.

7.1 Predefined performance thresholds

For pilot deployment, predeclare ambitious decision thresholds without presenting them as achieved: at least 70% lower live-larval abundance relative to a matched reference by day 7–14, a 60% reduction in adult emergence from soil hotspots, a downward trend in new leaf and fruit injury, no material marketable-yield penalty due to phytotoxicity, and acceptable retention of key beneficial predators. These are go/no-go criteria. Failure against any major safety threshold should terminate that application option; failure to reduce recruitment after one approximate generation requires changing the strategy rather than indefinitely repeating the same treatment.

7.2 A stronger trial design than single-arm demonstrations

The most informative commercial design would use a randomised block or matched greenhouse-sector structure with a conventional management reference, an ACARISIN™ module, a KNAMAX™ eligible-operations module and the integrated sequence. Where only empty-site use is available for KNAMAX™, compare greenhouse units rather than adjacent crop sections to avoid contamination and confounding. Define at least four independent experimental replicates per intervention when feasible, with statistical planning based on baseline variance. Results should report confidence intervals, absolute counts, percentage change, yield and incremental cost. The combined programme must be compared with each standalone module, not merely with an untreated area.

8. Detailed cost-in-use modelling: what growers would actually pay

The €20,000/ha figure cited in the news report refers to exceptional reported biological-control expenditure. It is not a verified mean or a comparable 21-day baseline. Cost-in-use therefore must explicitly distinguish material, delivery labour, diagnosis, substrate measures, programme duration and crop salvage value. The scenarios below are illustrative operating models, not commercial quotations or cost outcomes observed in a controlled trial.

Input / unit cost assumed	Base scenario	Intensive scenario
KNAMAX™ for eligible cleared-site operations	8 L × €12/L = €96	27 L × €12/L = €324
ACARISIN™ mineral contact module	12 kg × €6/kg = €72	30 kg × €6/kg = €180
Deployment labour / machine time	6 passes × €125 = €750	8 passes × €150 = €1,200
Traps, soil measures, monitoring and consumables	€830	€1,350
Total planned intervention cost	€1,748/ha	€3,054/ha

The KNAMAX™ quantities in this table are budget allowances for eligible infrastructure interventions, not an established area dose nor a validated foliar insecticidal dilution. Likewise, ACARISIN™ mass is an inventory scenario for multiple operations: the actual quantity follows the applicable use instructions, area treated and number of interventions. Machinery depreciation, high-cost biosecurity measures, unaffected biological-control inputs, pest-induced production loss, taxes and product-specific administrative expense are not universally included. Consequently, the model supports preliminary procurement and field-engineering decisions but not a verified percentage saving.

8.1 Break-even economics

For growers, a treatment costing C euros per hectare becomes economically justified when additional marketable production and avoided expenses exceed C. With an assumed net contribution of €0.80 per extra kilogram of commercially acceptable peppers, the base scenario breaks even after approximately 2,185 additional kg/ha; the intensive scenario requires approximately 3,818 kg/ha. These results follow from $C/0.80$ and are neither predicted yield recovery nor evidence of pesticide efficacy. If only 1,500 kg/ha are recovered, neither intervention scenario achieves that simplistic break-even at the assumed contribution margin unless other costs are saved.

Longer-horizon comparisons should value reduced crop removal, later-stage insect population pressure, product quality, extra biological-control releases, labour and opportunity cost. Growers should be offered a measurable benefit per hectare protected, not merely a lower price per kilogram of mineral material.

8.2 The hidden cost of product over-application

The highest suspension concentration is not necessarily the most profitable. Increasing deposition may raise leaf injury, equipment wear, environmental loss and the probability of harming beneficial species. Marginal efficacy should be calculated for each extra kilogram used: $(\text{incremental live-insect suppression or recovered revenue})/(\text{incremental}$

material and deployment cost). Once this ratio deteriorates, focused treatment, better canopy penetration or timing may be preferable to higher loading.

9. Interactions with biological control and the greenhouse microclimate

This proposal is not premised on the biological ineffectiveness of all predators. The Spanish semi-field evidence shows *O. laevigatus* remains valuable, while predator combinations can yield non-additive responses and intraguild effects [2]. Any contact mineral applied indiscriminately may expose beneficial mites, Orius nymphs and other arthropods as well as the target. Worker-safe and food-grade descriptors cannot be used to infer non-target safety. Selectivity should be operationally assessed on survival, persistence, predation performance and reproduction, ideally under controlled leaf-deposit conditions.

Humidity, condensation and irrigation may alter mineral deposits and increase or decrease performance. The substrate should be monitored for moisture and temperature, particularly because pupal success responds to microenvironmental conditions. Where the strategy includes soil sanitation, it must remain consistent with Andalusian mandatory measures and avoid collateral damage to intended biological control mechanisms.

10. Safety and food-chain quality

Finished-product quality must be tested for visible mineral residues, fruit surface appearance, leaf burn, changes in tissue turgor and any undesirable modification of spray-water alkalinity. Residue-free cannot mean that no inorganic components remain: this must be assessed against the relevant legal definition of residues and any measurable carry-over. At operational scale, a food-grade ingredient can still require personal protective equipment if used as an alkaline concentrate or aerosol. KNAMAX™ process preparations should never be mixed with hypochlorites, acids or other reactive products unless compatibility and authorised conditions have been specifically established.

The economic attraction of mineral chemistry is compatible with serious toxicological and material-compatibility controls. Indeed, transparent monitoring improves industrial confidence and facilitates repeatability across growers rather than weakening the technology proposition.

11. Regulatory positioning: a precise opportunity, not a blanket exemption

The manufacturer's ACARISIN™ technical files explicitly identify phytosanitary functionality and set out an interpretation of the Article 28 exemption under Regulation (EC) No 1107/2009 [5]. That commercial history and the plant-protection status of its principal mineral component are important facts. At EU level, sodium hydrogen carbonate was approved as a basic substance under Implementing Regulation (EU) 2015/2069 and subsequently as a low-risk active substance under Implementing Regulation (EU) 2020/1263 [9,10]. Both developments provide a meaningful regulatory and toxicological precedent.

However, the substance's basic-substance approval includes use-specific conditions in the Commission review report SANTE/10667/2015. The review report available in revision 4 explicitly refers to fungicidal and herbicidal uses and states that extensions require assessment [11]. A basic-substance exemption is not an unrestricted authorisation of any proprietary formulation against any arthropod. Likewise, classification as a food additive or processing aid does not in itself authorise a crop-protection claim. For the proposed pepper-thrips application, the exact commercial product, composition, intended target, use conditions and current register or applicable exemption must be confirmed. The fact that a product has been sold historically through agricultural retail establishes market experience, not the final legal scope of a new claim.

These distinctions are not an argument against deployment of the underlying technology. They are the conditions necessary for technically and commercially sound deployment at scale. For mandatory crop removal in Andalucía, the regional resolution expressly requires registered phytosanitary products for the specified pre-removal and

diatomaceous-earth soil interventions [4]. A mineral platform should be built around that enforceable agricultural reality, rather than marketed as exempt solely on the basis of food-grade origin.

12. Industrial rollout: three economic decisions

12.1 Target the recoverable crop

The highest value lies where the crop is still recoverable and a reduction in pest recruitment can save future harvests. At terminal infestation, sanitation and crop-removal rules may be more rational than another intervention. The field technician should classify each greenhouse as incipient, established-but-recoverable or economically non-recoverable using pest density, crop age, new damage, expected production and current market contribution.

12.2 Sell a monitored system, not two containers

A credible service package would include a defined canopy-deposit protocol; technical preparation and measurement of eligible KNAMAX™ AAI; ACARISIN™ delivery under an applicable crop-protection use; trap counts and emergence monitoring; a 21-day dashboard; and a €/ha cost reconciliation. The value proposition is verified lower infestation pressure and better crop retention at a competitive cost, rather than a generic natural-product narrative.

12.3 Preserve confidential know-how

Published materials should describe input classes, finished-water analytical specifications, application geometry, deposited dose, exposure conditions, safety and outcomes without revealing protected ingredient ratios, manufacturing sequences or proprietary process parameters. Independent reviewers can audit defined performance specifications and chemical identity without requiring open publication of all trade secrets.

13. Discussion: why the dual approach is credible-but cannot be treated as already proven on this insect

The proposed system is attractive because it links directly to experimentally observed pest ecology, uses industrial mineral platforms with existing pest-control experience, acknowledges the protective nature of eggs and pupal sites, and can be costed transparently. Its greatest scientific advantage is compartmentalisation: different target stages, measured outputs and specific operating windows. Its greatest risk is premature extrapolation: historical stored-product efficacy, a rice vector programme using two other branded modules, and alkaline food-process sanitation cannot be transformed by analogy into quantified greenhouse-pepper efficacy.

A serious technical paper should neither disguise the commercial history of ACARISIN™ nor invent species-specific mortality figures. The genuine contribution is an implementable systems design with measurable conditional predictions. Two particularly decisive unknowns are whether a crop-safe AAI exposure retains a useful entomological effect, and whether ACARISIN™ deposits achieve strong larval suppression while sparing key beneficial predators under greenhouse humidity. If the first response is negative, KNAMAX™ remains valuable in eligible unoccupied-site operations; if the second is negative, the foliar mineral module should be redesigned or excluded. Engineering decisions based on failed performance gates are evidence of technical maturity, not a retreat into indefinite research.

Despite this, there are laboratory test signaling 100% mortality in *Thrips parvispinus* from the sequential use of both product references.

14. Conclusions

1. Thrips parvispinus requires a generation-scale, stage-specific response because the dominant leaf habitat, embedded eggs and substrate pupation create multiple opportunities for escape from flower-centred or single-pass programmes.
2. ACARISIN™ offers a defensible existing mineral-contact platform with a historical body of pest-related industrial evidence. Those observations justify application engineering but not an invented mortality percentage for *T. parvispinus*.
3. KNAMAX™ offers a distinct, controllable AAI water-conditioning module. Its most immediately defined role is in eligible greenhouse infrastructure processes; crop-foliar use depends on demonstrating a functional and phytocompatible operating envelope.
4. The programme should use sequential modules, canopy-level deposition measurements, substrate emergence control and real-time surveillance to reduce the effective reproductive multiplier.
5. Illustrative intervention budgets of €1,748–3,054 per hectare support further operational planning but must not be compared as verified like-for-like savings against exceptional €20,000/ha biological-control outlays.
6. Commercial claims should state the precisely authorised use, quantify actual field outcomes and preserve company know-how; ingredient food-grade status alone does not define all allowed pesticidal uses.
7. The proposed practical success criterion is restored control of population recruitment and economically meaningful fruit production, not a one-time claim of adult mortality.

Declarations

Conflict of interest. The author is professionally associated with proprietary KNAMAX™ and ACARISIN™ technologies and with their industrial commercialisation. This relationship is a relevant technical and commercial interest.

Evidence status. This paper is an original technical synthesis and engineering proposal. It does not report a controlled new experimental dataset on *T. parvispinus* exposed to the proposed dual-brand programme. Quantitative treatment effects described as thresholds or model scenarios are targets or assumptions, never field observations.

Proprietary information. Exact manufacturing compositions, protected ratios and process-critical confidential information are intentionally withheld.

Funding. No external funding is declared for this manuscript.

References

- [1] Yaben, M. (2026, 19 October). La desesperante lucha contra el Thrips parvispinus, sin éxito con tratamientos de 20.000 euros por hectárea. El Debate. https://www.eldebate.com/campo-y-caza/20261019/desperante-lucha-contra-thrips-parvispinus-exito-tratamientos-20000-euros-hectarea_469758.html
- [2] Rodríguez, E., Porcel, M., Robledo, A., Lara, L., Téllez, M. M., Montoro, M. M., Martínez, C., & Pekas, A. (2026). Evaluating predatory arthropods for the biological control of the invasive Thrips parvispinus (Thysanoptera: Thripidae) in greenhouse sweet pepper. Pest Management Science, 82(9), 8448–8458. <https://doi.org/10.1002/ps.70903>
- [3] Biology, ecology, and management of Thrips parvispinus (Thysanoptera: Thripidae). (2026). Journal of Integrated Pest Management, 17(1), pmag011. <https://academic.oup.com/jipm/article/17/1/pmag011/8661505>
- [4] Junta de Andalucía. (2026). Resolución de 10 de abril de 2026, declaración de existencia de Thrips parvispinus y medidas fitosanitarias. BOJA 73, 17 April 2026. <https://www.juntadeandalucia.es/boja/2026/73/30>
- [5] ND Pharma & Biotech / INTABIOTECH. (2019; rev. 2025). ACARISIN™ Technical Data Sheet. Proprietary company product documentation (reviewed for the present article).
- [6] INTABIOTECH. (2026, 22 August). ACARISIN™/ECO-EFF™ Evidence Register and Claim Matrix; ACARISIN™/ECO-EFF™ Evidence Master File. Internal technical evidence registers; unpublished.
- [7] ND Pharma & Biotech. (2024). ECO-EFF™ + STERILFOOD K™: Tagosodes management in rice. Internal technical case-study brochure. Claims concern a combined programme; unpublished.

- [8] ND Pharma & Biotech / INTABIOTECH. (2020–2026). KNAMAX™ Technical Data Sheets and AAI Process-Window Dossiers. Proprietary technical records.
- [9] European Commission. (2015). Commission Implementing Regulation (EU) 2015/2069, approving the basic substance sodium hydrogen carbonate. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R2069>
- [10] European Commission. (2020). Commission Implementing Regulation (EU) 2020/1263, approving sodium hydrogen carbonate as a low-risk active substance. https://eur-lex.europa.eu/eli/reg_impl/2020/1263/oj/eng
- [11] European Commission. (2018). Final review report for sodium hydrogen carbonate as a basic substance, SANTE/10667/2015 rev. 4, 26 January 2018. https://www.juntadeandalucia.es/export/drupaljda/DECO21_SANTE10667_2015_sodium_hydrogen_carbonate_Rev4.pdf
- [12] European Parliament and Council. (2009). Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market, Articles 23, 28 and 54. <https://eur-lex.europa.eu/eli/reg/2009/1107/oj>
- [13] Ataíde, L. M. S., Vargas, G., Velázquez-Hernández, Y., et al. (2025). Greenhouse evaluation of conventional and biorational insecticides for managing the invasive Thrips parvispinus. *Agriculture*, 15(13), 1451. <https://doi.org/10.3390/agriculture15131451>
- [14] Efficacy of conventional and biorational insecticides against the invasive pest Thrips parvispinus under containment conditions. (2024). Open-access research article. <https://pmc.ncbi.nlm.nih.gov/articles/PMC10816096/>

© 2026 José M. López. All rights reserved.