DIETRICK INSTITUTE
Applied Insect Ecology

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RE: California Department of Pesticide Regulation Sustainable Pest Management Roadmap Strategic Plan

We appreciate the effort put into the Strategic Plan to implement the Sustainable Pest Management (SPM) Roadmap. The implementation of the SPM Roadmap is important. We need a ban on hazardous pesticides. Research points to the agricultural use of pesticides and herbicides as a contributing factor to biodiversity loss.[1] Bird losses follow insect losses.[2] The SPM Roadmap is critical to reverse biodiversity loss and we obviously cannot wait until 2050.

We would like to draw attention to a few critical Goals and Keystone and Priority Actions, 'leverage points' listed on page 21 in the SPM Roadmap. There appear to be no planned steps for the next four years to implement these five critical actions and goals:

1. Full scope of the "Keystone Action" to "Prioritize Prevention"
2. Explicit removal of structural barriers so that all licensed Pest Control Advisors are "incentivized to promote SPM in the field" (pages 46-48)
3. Implementation of "a system of incentive and financial risk management…to drive widespread adoption of SPM" (page 49)
4. Foundational steps in the strategy toward ensuring development of the "Keystone Action" to "Invest in Building SPM Knowledge".
5. Substantive and timely plans to "Improve California's Pesticide Registration Processes" particularly for evaluating currently registered pesticides (page 26)

The SPM Roadmap was developed by a broad stakeholder SPM Work Group to incorporate a comprehensive suite of actions to achieve "The North Star" (long-term, high-level, aspirational goal that motivates those involved). The Work Group began by agreeing on its North Star: "We believe that by implementing the Roadmap's recommendations, California will by 2050 be able to *eliminate the use of Priority Pesticides by transitioning to sustainable pest management practices,* and SPM has been adopted as the de facto pest management system in California." Prevention and incentives are priority actions toward that North Star, but a keyword search, finds no mention of either. Apparently transparent steps for prevention and incentives are not planned for the next four years to ensure Roadmap 2030 goals are met.

[1] https://www.annualreviews.org/doi/10.1146/annurev-ento-011019-025151#:~:text=Many, if not most, of,become increasingly unfriendly to nature.

[2] Douglas W Tallamy, W Gregory Shriver, Are declines in insects and insectivorous birds related?, *Ornithological Applications*, Volume 123, Issue 1, 1 February 2021, duaa059, https://doi.org/10.1093/ornithapp/duaa059

Plans and first steps to implement pest prevention and the recommended PCA and grower incentives are major lines of action toward the North Star. Immediately and publicly promulgating your plans for pest prevention and incentives will signal to the entire community a disruptive societal paradigm shift. This will then help you to clarify the prioritization of registered pesticides for evaluation. The need for many pesticides will decline as you declare your intention to incentivize and mitigate risks by SPM practices.

GOALS STILL IN NEED OF A STRATEGIC PLAN:

Prioritize Prevention. Prevention is prioritized in the SPM Roadmap as "urgent and foundational" by proactively preventing the establishment of new invasive pest species, and by proactively eliminating pest-conducive conditions". To many, prevention means border interception and quarantine of invasive pests. However, eliminating pest-conducive conditions can also occur through promoting soil biodiversity, since interactions between soil organisms drive the phenomena of pest-suppressive soils. A key oversight in the Strategic Plan is the lack of attention paid to agroecological farming approaches that increase soil health and biodiversity. These practices, which can include cover cropping, diverse crop rotations, and organic carbon inputs are often low-cost, environmentally friendly, and confer multiple co-benefits compared to reactive measures. It is extremely important to develop a robust strategy for developing and promoting these agroecological techniques, including ensuring that technical assistance is available to disseminate state-of-the-art knowledge about pest prevention. One step in your plan should be to request that the CDFA's Belowground Biodiversity Advisory Committee produce a report on the correlation between soil biodiversity and pest prevention.

CDFA's Report Soil Biodiversity in California Agriculture outlines that the relationship between biodiversity and ecosystem functions is a rich area of both theoretical and empirical ecological research. Plant pathogens are a natural component of soil biodiversity, and indeed, are often present in small quantities in any soil. However, in systems with lower soil biodiversity, it can be easier for plant pathogens to explode in abundance due to the lack of competition and predation from other soil organisms. For example, plant tissues are normally colonized by hundreds of different species of bacteria and fungi that can coexist with the plant without serious harm. In order for pathogens to have a negative effect on their host, they must find uncolonized plant tissues or compete with resident bacteria and fungi for space. The presence of a diverse set of non-pathogenic microorganisms in soils and plant tissues can dramatically reduce disease incidence in crop plants.[3] Further studies on above and below-ground impacts of biodiversity on pest and disease immunity in California settings can help expand on this phenomena.

We share some scientific principles we have understood for over 40 years and some more recent discoveries. There are over 30 scientific papers that on the surface explain the molecular biology and electromagnetic signals between plants and associated arthropods demonstrating signaling between cells about their growth, health and affecting insect and other arthropod behavior.[4] [5] In an appendix to this letter, we share some of the more recent science that helps us think through the sequence of testing and implementation of farming practices that achieve plant health and immunity to pests and diseases.

[3] Arnold, A. E., et al (2003) Fungal endophytes limit pathogen damage in a tropical tree 100 (26) 15649-15654, PNAS https://doi.org/10.1073/pnas.2533483100

[4] Callahan, Phillip S. (1965-1975). 36 published papers summarized on Free Library "Electromagnetic communication and olfaction in insects".

[5] Callahan, Phillip S., 1975. Insect antennae with special reference to the mechanism of scent detection and the evolution of the sensilla. International Journal of Insect Morphology and Embryology, Vol 4, Issue 5,(381-430).

Here are a few more examples of ways that biodiversity-based farming systems comprise the essential meaning of pest prevention:

- The below-ground microbiome facilitates access by plants to calcium, phosphorus, sulfur and other minerals that are in the soil, but are not available without the inter-microbial interactions.
- Arbuscular mycorrhizal fungal hyphal networks in soil serve as electrical conduits facilitating the transfer of defense signals.
- Fungi and bacteria colonize inside and on the outside of plants as well as in the root zone in a close symbiotic relationship.
- Plant species richness has an effect on crop health. Plant communities of between eight and sixteen species support each other in the root zone to increase nutrient cycling and fertility. Arbuscular mycorrhizal fungi colonizing diverse plant roots, when not disturbed by tillage, contribute to these high-functioning plant communities. It is a challenge to measure or model this complexity. It is apparently not always a straight-line linear correlation between diversity and systemic functionality. There are tipping points where the next higher level of diversity accelerates all healthful functions in the plant in a steeper curve for phenomena such as soil organic carbon deposition, nitrogen availability, and the availability, potency, and/or rapid-response of molecules involved in pest and disease prevention defense mechanisms. Studies also show attrition of species and stabilization of the community over time.
- The Jena Experiment generally shows that reaching a community tipping point of species richness as well as functional group composition are important drivers.[6] A meta-analysis from 95 studies showed that soil microbial biomass and ecosystem carbon storage was significantly enhanced by plant diversity, with stronger effects on aboveground biomass than on soil carbon content.[7] These phenomena are central to expediting carbon neutrality, and synergistic with the North Star.

An appendix to this letter explains more about the soil food web, terpenoid mediated communication, plant sap as an indicator (beyond soil tests) of what plants need. Some understanding of the complexity of microbe-plant-pest interactions should be required learning for Pest Control Advisors and Certified Crop Advisors. It would be helpful if you would reveal in your Strategic Plan the steps you will be taking within your Strategic Plan to deliver this new curriculum. There is so much to help farmers learn about why crops attract pests and diseases and opportunities provided by agroecology to accelerate the shift away from the "see a bug, kill a bug" paradigm to one of the Roadmap's vision of a community of experts supporting farmers and other pesticide users to work with nature to achieve pest prevention.

2. PCAS Incentivized to Promote SPM. The Roadmap has a goal that "by 2030, all PCAs have received meaningful training in SPM and are incentivized to promote it in the field. [In the future] PCA advice will be guided by SPM principles and practices and their recommendations will not be commission-driven." (page 46) The conflicts of interest inherent in the PCA profession must be addressed legislatively as soon as possible with immediate strategic planning to achieve this recommendation described on page 48 of the Roadmap. This alone could reduce by more than

[6] Weigelt A, Marquard E, Temperton VM, Roscher C, Scherber C, Mwangi PN, Felten S, Buchmann N, Schmid B, Schulze ED, Weisser WW (2010). The Jena Experiment: six years of data from a grassland biodiversity experiment. Ecological Archives E091-066. https://doi.org/10.1890/09-0863.1

[7] Xu S, Eisenhauer N, Ferlian O, Zhang J, Zhou G, Lu , Liu C, Zhang D (2020). Species richness promotes ecosystem carbon storage: evidence from biodiversity-ecosystem functioning experiments https://doi.org/10.1098/rspb.2020.2063

half the recommendations of unnecessary pesticide treatments and start to build trust with CDPR among those directly impacted by avoidable exposure.

3. Risk management incentives. The Roadmap aims by 2030 to implement a "system of incentives and financial risk management that integrates supply chain partners, educational institutions, private financial markets, and state and federal risk management programs to drive widespread adoption of SPM." (page 490) We would like to see concrete steps named in the plan toward this system of incentives and multipronged grower risk management by 2028 so that programs are working well for growers by 2030. All farmers, regardless of their size or resources, should as a result of this strategic plan look forward to a process for calculating and making a claim for a financial loss resulting from the choice of an SPM strategy over a chemical strategy. Some PCAs ask us how this will be paid for. Solid training of PCAs in SPM will ensure that claims are not great. They may be grower-financed; growers stand to gain so much peace of mind. It should be included in AB408 the Climate-resilient Farms, Sustainable Healthy Food Access, and Farmworker Protection Bond Act of 2024. Voters should also gain much peace of mind from such an insurance program. Your plan must set out steps to develop this new knowledge base and set of skills for PCAs and CCAs to assist in a systematic decision-tree evaluation of the SPM strategy so that it is not a wild gamble. PCA's could be certified to review the conditions for validating a farmer's claim. An app could be developed. Such support and risk mitigation would go a long way to relieve fear of risk for advisors as well as growers.

4. Invest in Building SPM Knowledge and launch pilot Regional Pest Management Collaboratives. The Roadmap has a critical goal that "by 2030, every farm in California has access to free or affordable SPM education, training, and independent technical advice that is relevant to its crops, region, farm size, pest pressures, and language needs." (page 39) With programs in place to incentivize PCA's to promote SPM and end-users to take the risk of using SPM strategies without fear of financial loss, the state can even more confidently organize the proposed Regional Pest Management Collaboratives to guide investment in research, education, training goals. This is best launched once we have the above incentives and risk mitigation at least defined. The community participating in the Regional Pest Management Collaboratives needs to know that PCAs and growers are being incentivized to take advantage of learning and services from the Collaboratives. The Regional Pest Management Collaboratives are valuable geographic centers. The Strategic Plan must include a vision for the Collaboratives with a first step of at least three pilot Collaboratives. The USDA National Institute of Food and Agriculture Regional IPM Centers are models for how to facilitate the establishment of these centers as high-profile dynamic resources for any and all collaboration.

5. Improve California's Pesticide Registration Processes for evaluating and banning currently registered hazardous Priority Pesticides. A strategic plan that focuses on the above goals for 2030 in the Roadmap will help clarify which are "Priority Pesticides" going forward. The proposed pace of evaluating only two priority pesticides per year is insufficient given the urgency of addressing pesticide-related exposure, especially for wildlife. CDPR should be moving much farther ahead of the US-EPA, which is lagging behind other major agricultural nations in banning hazardous pesticides. Seventy-two pesticides banned or in process of phase-out in the EU account for more than a quarter of agricultural pesticide use in the USA.[8]

[8] Donley, N. The USA lags behind other agricultural nations in banning harmful pesticides. *Environ Health* 18, 44 (2019). https://doi.org/10.1186/s12940-019-0488-0

We need evaluation of active ingredients and registered formulations using the precautionary principle, before registering or reregistering any pesticide. Roundup was registered without complete evaluation of formulations. Where are studies for formulations of glyphosate. Apparently EPA only tested glyphosate and not the formulations, though Roundup is over 100 times more toxic with more negative effects than glyphosate on genotoxicity assays and molecular profiling in rats.[9] The half-life of the Roundup adjuvant POEA (21–42 days) is longer than that of glyphosate alone (7–14 days) in aquatic environments.[10] Moreover, EPA's 2021 evaluation of glyphosate states that there is moderate evidence that 93% of all species and 96% of all critical habitats are Likely Adversely Affected (LAA) by glyphosate.[11] This EPA finding points to the urgency to deregistering pesticides that have such harmful effects on the environment. This concern is on top of our long-standing question whether the original toxicity studies were done properly, and in the cases of fraud, were repeated ethically.

Completing pesticide evaluations more rapidly is imperative, especially when the EPAs findings are so extreme. Transparency about the toxicity studies is also needed. A much speedier timeline can also be achieved through collaboration with the European Commission's Standing Committee on Plants, Animals, Food and Feed. An immediate ban of clothianidin, imidacloprid, and thiamethoxam is fully justified by the studies on which the Commission bases its ban of these three neonicotinoids.[12] Numerous other highly hazardous pesticides can then be efficiently evaluated in such an international collaborative process with the toxicologists that have been recommending the bans of hazardous pesticides in the EU, Brazil and China.

Pesticide industry lobbyists say that neonics are needed to kill ACP. Find out how much of their salary or organization is supported by pesticide companies. We attended the annual meeting of the Association of Applied IPM Ecologists on November 6-7. Many observant independent PCAs cannot find ACP and deplore the state's quarantine and spray program as worse than senseless. The psyllid can be controlled biologically by stopping toxic agronomic practices and starting practices that build truly healthy trees. There are multiple valuable co-benefits to using agroecology and plant health solutions. Roadmap programs can educate and guide PCAs to see through and reject chemical input-based assumptions that aren't born out in the field.

We expect an accelerated process for hazardous pesticides. The Strategic Plan needs to show how you will pursue the agroecological knowledge base for prevention, the incentives and risk mitigation, and efficient banning of hazardous pesticides.

Thank you for your attention to these matters.

Sincerely,
Jan Dietrick, MPH
Executive Director

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[9] Robin Mesnage, M Ibragim, D Mandrioli, LFalcioni, E Tibaldi, FBelpoggi, I Brandsma, E Bourne, El Savage, C A Mein, Ml N Antoniou, Comparative Toxicogenomics of Glyphosate and Roundup Herbicides by Mammalian Stem Cell-Based Genotoxicity Assays and Molecular Profiling in Sprague-Dawley Rats, *Toxicological Sciences*, Volume 186, Issue 1, March 2022, Pages 83–101, https://doi.org/10.1093/toxsci/kfab143

[10] In vitro effects of glyphosate-based herbicides and related adjuvants on primary culture of hemocytes from Haliotis tuberculata, Fish & Shellfish Immunology, Volume 100, 2020, Pages 1-8, ISSN 1050-4648, https://doi.org/10.1016/j.fsi.2020.02.058.

[11] https://www.epa.gov/endangered-species/final-national-level-listed-species-biological-evaluation-glyphosate#executive-summary

[12] Erik Stockstad, Union expands ban of three neonicotinoid pesticides, 2018. ScienceInsiderEurope.

Appendix on Pest Prevention by Agroecological Approaches and New Monitoring Approaches

CDFA's Report Soil Biodiversity in California Agriculture states, "The relationship between biodiversity and ecosystem functions is a rich area of both theoretical and empirical ecological research. Conceptually there are two mechanisms by which diversity can positively affect function and help in managing agricultural soils."[13] There are complex interactions in diverse communities. For example, in 73% of 200 studies reviewed, intercropping was associated with disease control.[14] There is a growing knowledge base about practices that render typical "pathogenic" fungi not functionally pathogenic and can be harmless in a biodiverse ecosystem.

Since Callahan's work demonstrating the "bioelectrical" signals between plants and associated arthropods in the 1990s, there are more recent findings. The best soil health consultants have long used Brix readings and now a more sophisticated measure of plant health called plant sap analysis. These are the tests that correlate plant fertility with plant immunity for regenerative farmers to improve their plant health care practices, i.e. what treatment does the crop need to be immune or unattractive to pests because of myriad pathways of healthy functioning. What must I stop doing so my plants are not "disposable" to be cleaned up by pests and diseases because they are nutritionally poor or even "sick". We hear that in citrus orchards and backyard citrus trees where the soil is armored, ideally with cover crops, and no chemicals are destroying the soil food web (no soil antibiotics like Roundup are used), and where ants are managed, the pest control scouts find an abundance of natural enemies of Asian citrus psyllid and no psyllids.

Regenerative farmers use an inexpensive field refractometer to get a Brix reading to evaluate fertility. The Brix scale is nominally sugar concentration, but is actually total dissolved solids, and is taken as an index of photosynthetic efficiency. A Brix "percentage of total dissolved solids", is an immediate in-field measurement of photosynthetic efficiency and provides a comparison among plants and over time about plant nutrition and health. The observation is that the higher the Brix of a plant, the lower the incidence of pests and disease. Insects can feed on plants at different Brix levels, ie. when plants are at 3-6 Brix, aphids show up, 10-12 Brix grasshoppers are feeding, and over 14 Brix you rarely see pests or disease.

Often soil tests indicate minerals are present; however, the ecosystem lacks what will make those minerals available. A Brix reading can sometimes reveal what type of foliar application will help the crop overcome a fertility deficiency. Brix can explain presence/absence of pests and disease in a few minutes and help forecast crop longevity, nutrient density and flavor, and profitability.

The same types of molecular mechanisms drive photosynthetic efficiency and building of Soil Organic Matter, for disease prevention and carbon deposition. These goals are synergistic. Terpenoids can be molecules given off by healthy plants that make them less easy for plant-feeding insects to chew compared to sick plants. Some terpenoids mediate intra- and inter-species communication. Terpenoids increase calcium ions and depolarization causing a protective response lasting up to five days.[15] "All plants synthesize a suite of several hundred terpenoid compounds with roles that include phytohormones, protein modification reagents, anti-oxidants,

[13] M. Loreau *et al.* ,Biodiversity and Ecosystem Functioning: Current Knowledge and Future Challenges.*Science***294**,804-808(2001).DOI:10.1126/science.1064088

[14] Mark A. Boudreau (2013).Diseases in Intercropping Systems. Annual Review of Phytopathology 51:1, 499-519

[15] Sharma, E., Anand G., & Kapoor, R. (2017). Terpenoids in plant and arbuscular mycorrhiza-reinforced defence against herbivorous insects. Annals of Botany, ncw 263.

and more. Different plant lineages also synthesize hundreds of distinct terpenoids, with the total number…estimated in the scores of thousands. Phylogenetically restricted terpenoids are implicated in defense or in the attraction of beneficial organisms."[16]

Best management practices for tree health prolong the life and productivity of citrus trees that are infected with the Huanglongbing (HLB) disease. EB92-1 bacteria causes "induced resistance" that slows HLB symptoms.[17] An antibody molecule in stingrays may be developed into a treatment that would prevent or cure disease in well-cared for trees.[18] Electron micrographs showed the HLB bacteria disappeared from the tree phloem of trees given a program of optimum nutrition.[19] Ecological PCAs believe that CDFA spraying of citrus is not as sustainable as would be a program to conserve the psyllid's natural enemies and build disease resistance in the trees; however, the sustainable approach is blocked by the state spray program, with no interest in analyzing farming systems where psyllids are not found AND where HLB is present and trees are asymptomatic.

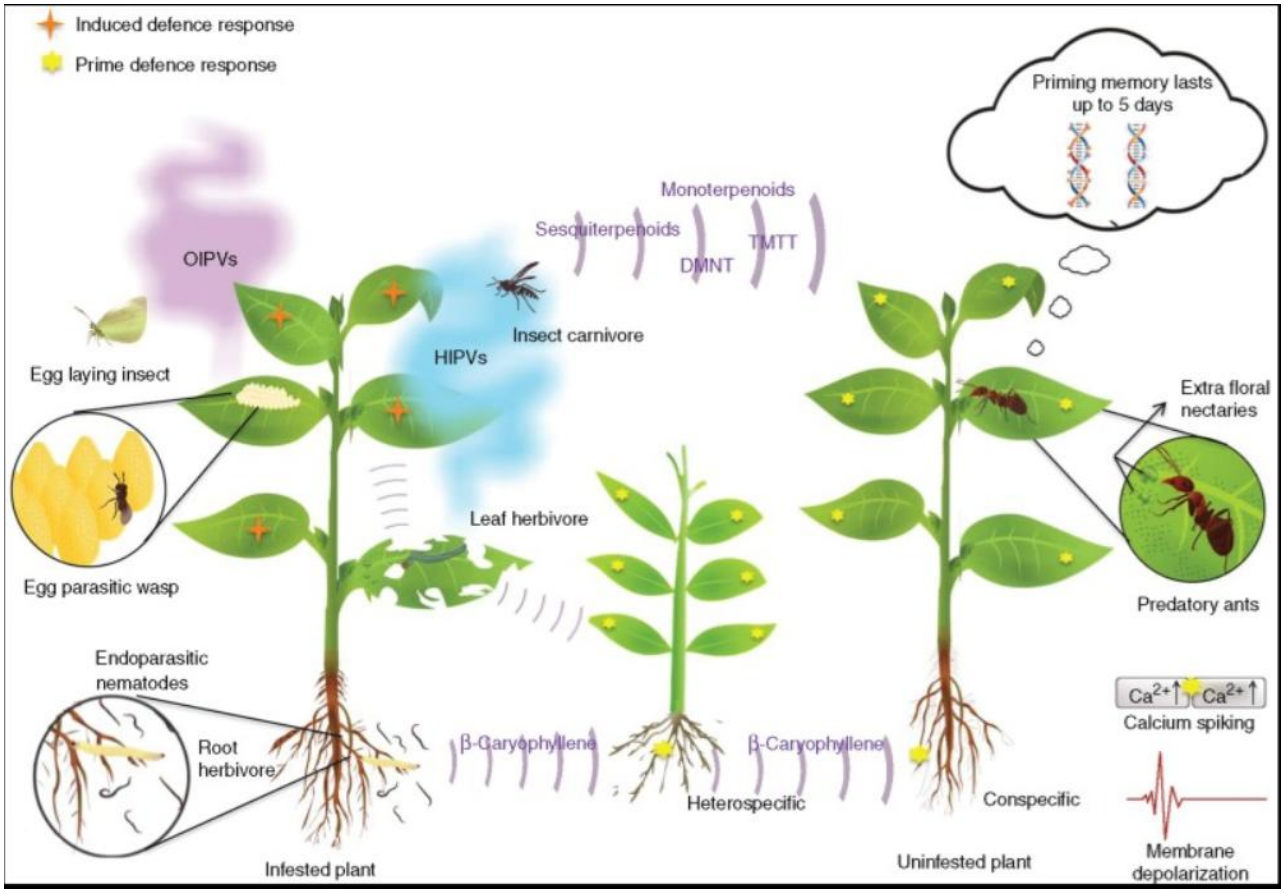

Fig. 1. Overview of terpenoids in plant defense against herbivorous insects. Volatile terpenoids that belong to the HIPVs (herbivore-induced plant volatiles) and OIPVs (oviposition-induced plant volatiles) are released in response to herbivore attack and oviposition, respectively. Terpenoids induce defense responses in the systemic parts of the same plant. These volatiles attract insect carnivores that feed on the herbivores, thereby inducing indirect defense in plants,

[16] Pichersky E, Raguso RA. Why do plants produce so many terpenoid compounds? New Phytol. 2018 Nov;220(3):692-702. doi: 10.1111/nph.14178. Epub 2016 Sep 8. PMID: 27604856.

[17] Borger, R. UFl, Institute of Food & Agricultural Sciences (2022). Promising Advancements in Biocontrol Treatment that Slows Citrus Greening.CA Fruit and Vegetable Magazine.

[18] Markham, K. USDA-ARS Communications (2023). Could Stingrays be the Key to Saving Citrus from Deadly HLB Disease? .CA Fruit and Vegetable Magazine

[19] Pavich, S and Makam, S. Foliar Nutrient Sprays for HLB (2020). Healthy Citrus Webinar, Dietrick Institute for Applied Insect Ecology.

and prime neighboring…plants. The perception of terpenoids by neighboring plants results in influx of calcium ions and membrane depolarization…Terpenoids also affect tritrophic interactions in soil. [From Sharma, et al, 2017.]

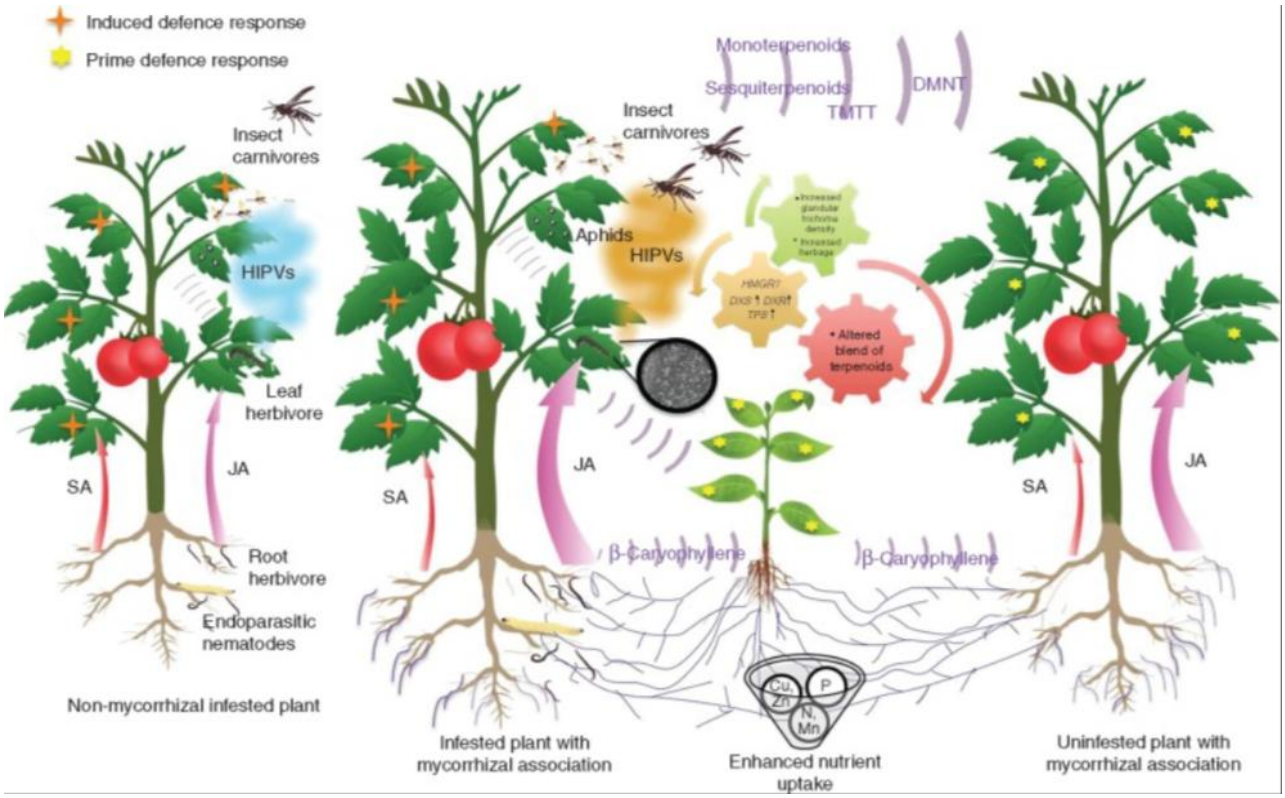

Fig. 2. Overview of arbuscular mycorrhiza (AM)-reinforced defense against herbivorous insects. Plants colonized by AM fungi are more tolerant by virtue of superior growth and nutrient uptake. Formation of AM may result in increased glandular trichome density, availability of substrates, induction of MEP (higher expression of DXS and DXR) and MVA (higher expression of HMGR) pathways, and induction of terpene synthases (TPSs). These factors in various combinations result in changes in the terpenoid profile in mycorrhizal (M) plants, inducing both direct and indirect defense responses against herbivore attack in the plant. Mycorrhizal colonization results in amplification of a wound signal, leading to priming of neighboring plants. Common mycelial networks (CMNs) serve as signaling conduits between interconnected plants under herbivore attack. JA, jasmonic acid; SA, salicylic acid.[From Sharma, et. al. 2017.]

These plant defensive strategies against herbivorous insects are working, for example, when the bite of an insect can cause a plant to emit terpenoids that have electrical signals that attract beneficial insects to eat the plant-chewing insect. [20] Imagine and be curious about the potential of plants. It is not really “healthy soil” but “healthy plants” that are doing the work, partnering with microbes in the soil matrix, making energy and feeding the underground community and releasing protective molecules.

These bioelectrical and biochemical pathways and signals elevate our vision about the immense power of “Prioritizing Pest Prevention”. The study of these phenomena is probably the tip of the iceberg, but we must promulgate the science that we have so that policy-makers, planners, regulators and licensed professionals can guide farmers to release the potential of healthy agroecosystems and protect people, insects, and other wildlife.

[20] Farmer, Edward E, Yong-Qiang Gao, Gioia Lenzoni, Jean-Luc Wolfender and Qian Wu, 2020. Wound- and mechanostimulated electrical signals control hormone responses, New Phytologist: 227(1037-1050)