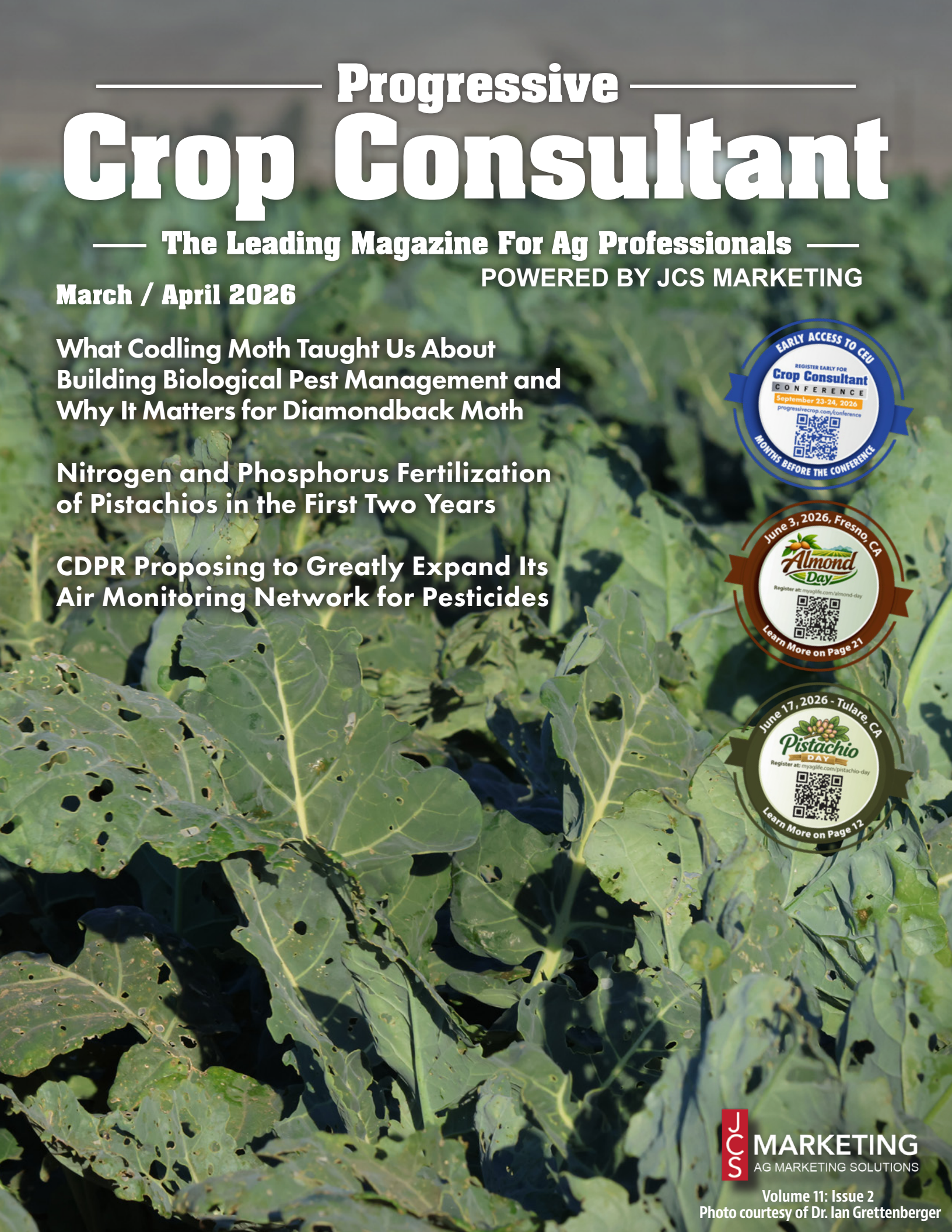
Progressive
Crop Consultant
The Leading Magazine For Ag Professionals
POWERED BY JCS MARKETING
March / April 2026



What Codling Moth Taught Us About Building Biological Pest Management and Why It Matters for Diamondback Moth

Nitrogen and Phosphorus Fertilization of Pistachios in the First Two Years

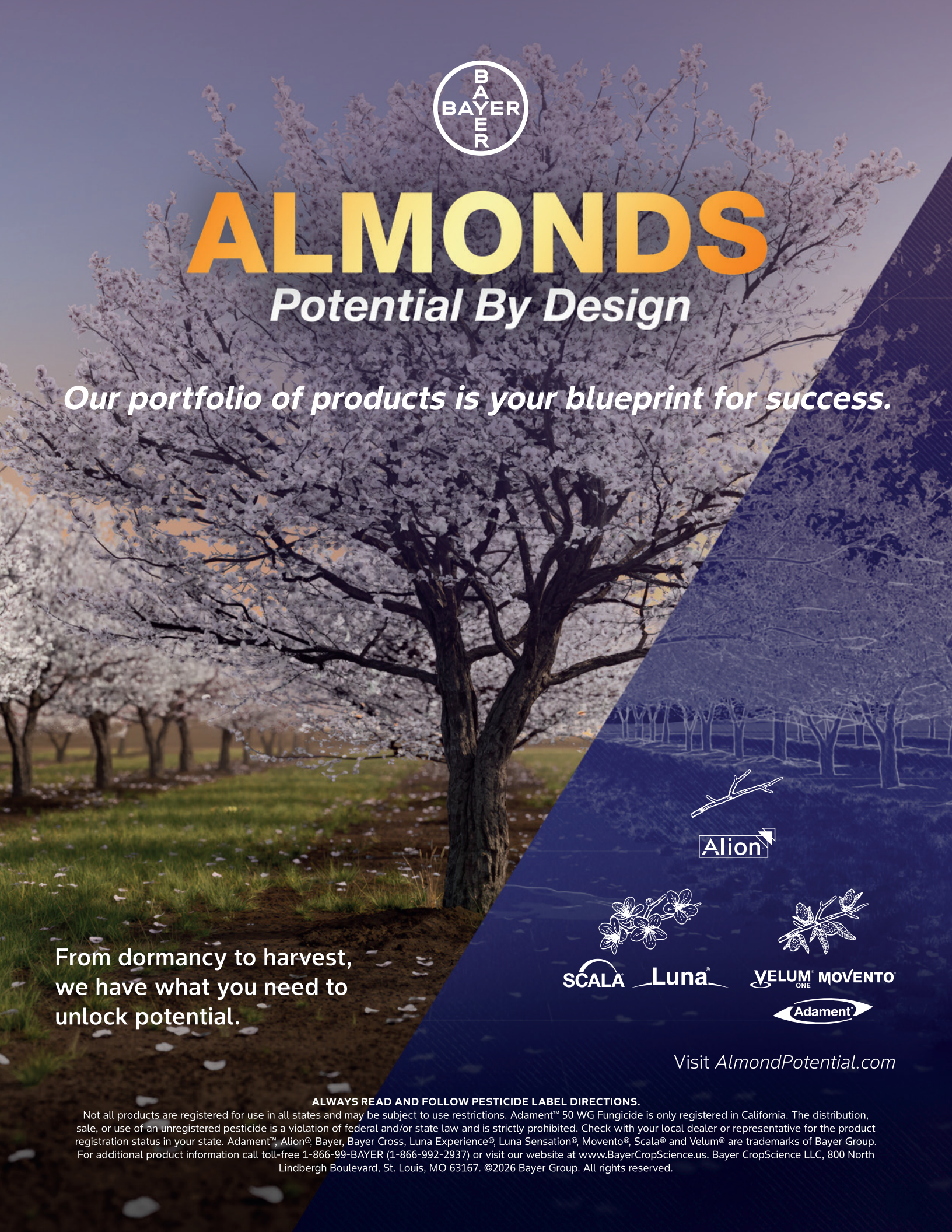
CDPR Proposing to Greatly Expand Its Air Monitoring Network for Pesticides

EARLY ACCESS TO CEU
REGISTER EARLY FOR
Crop Consultant
CONFERENCE
September 23-24, 2026
progressivecrop.com/conference
MONTHS BEFORE THE CONFERENCE

June 3, 2026, Fresno, CA
Almond Day
Register at: myaglife.com/almond-day
Learn More on Page 21

June 17, 2026 - Tulare, CA
Pistachio DAY
Register at: myaglife.com/pistachio-day
Learn More on Page 12

JCS MARKETING
AG MARKETING SOLUTIONS
Volume 11: Issue 2
Photo courtesy of Dr. Ian Grettenberger



ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS.
Not all products are registered for use in all states and may be subject to use restrictions. Adament™ 50 WG Fungicide is only registered in California. The distribution, sale, or use of an unregistered pesticide is a violation of federal and/or state law and is strictly prohibited. Check with your local dealer or representative for the product registration status in your state. Adament™, Alion®, Bayer, Bayer Cross, Luna Experience®, Luna Sensation®, Movento®, Scala® and Velum® are trademarks of Bayer Group. For additional product information call toll-free 1-866-99-BAYER (1-866-992-2937) or visit our website at www.BayerCropScience.us. Bayer CropScience LLC, 800 North Lindbergh Boulevard, St. Louis, MO 63167. ©2026 Bayer Group. All rights reserved.

Progressive
Crop Consultant

IN THIS ISSUE

4 Thinking Like a CEO in Crop Consulting

6 What Codling Moth Taught Us About Building Biological Pest Management and Why It Matters for Diamondback Moth



06

14 Managing Plant Parasitic Nematodes in Walnuts Under Changing Production Conditions

18 Reduced Fertilizer Application Rates Demonstrate Measurable Returns in California Almond Production



18

24 Nitrogen and Phosphorus Fertilization of Pistachios in the First Two Years

28 Limitations of Soil Applied Biologicals for Lettuce Fusarium Wilt Management

32 CDPR Proposing to Greatly Expand Its Air Monitoring Network for Pesticides



24

JCS MARKETING
AG MARKETING SOLUTIONS

PUBLISHER: Jason Scott
Email: jason@jcsmarketinginc.com
EDITOR: Kristin Platts
Email: kristin@jcsmarketinginc.com
PRODUCTION: design@jcsmarketinginc.com
Phone: 559.352.4456
Fax: 559.472.3113
Web: www.progressivecrop.com

CONTRIBUTING WRITERS & INDUSTRY SUPPORT

Andreas Westphal
Department of Nematology, University of California, Riverside

Dylan Rogers
Account Manager, AgroLiquid

Evan Tamayo
MS Student, Plant Protection Science, Cal Poly San Luis Obispo

Josue Diaz
Lab Manager, Betteravia Farms

Max Youngren
MS Student, Plant Protection Science, Cal Poly San Luis Obispo

Matthew J. Grieshop, Ph.D.
Director Grimm Family Center for Organic Production and Research at Cal Poly

Phoebe Gordon
Orchard Systems Advisor for Madera and Merced Counties; University of California Cooperative Extension

Roger A. Isom
President/CEO Western Tree Nut Association

Shunping Ding
Associate Professor, Dept. of Plant Sciences and Wine and Viticulture, Cal Poly San Luis Obispo

UC COOPERATIVE EXTENSION ADVISORY BOARD

Steven Koike
Tri-Cal Diagnostics

Kevin Day
UCCE Pomology Farm Advisor, Tulare and Kings Counties

Elizabeth Fichtner
UCCE Farm Advisor, Kings and Tulare Counties

Katherine Jarvis-Shean
UCCE Orchard Systems Advisor, Sacramento, Solano and Yolo Counties

Jhalendra Rijal
UCCE Integrated Pest Management Advisor, Stanislaus County

Mohammad Yaghmour
UCCE Farm Advisor, Kern County

The articles, research, industry updates, company profiles, and advertisements in this publication are the professional opinions of writers and advertisers. Progressive Crop Consultant does not assume any responsibility for the opinions given in the publication.

Thinking Like a CEO in Crop Consulting

By **JASON SCOTT** | *Publisher, Progressive Crop Consultant*



SPEND ENOUGH TIME AROUND REALLY good crop consultants, and you start to notice something.

The best ones are not just good agronomists. Yes, they know pests. They understand fertility. They can spot problems in a field before anyone else notices. But what really separates them is how they think.

The best crop consultants think like CEOs.

Most consultants operate like technicians. The best ones operate like business owners who happen to know agronomy. That difference might sound small, but it changes everything. It changes how they manage their time. It changes the kind of growers they work with. It changes how they price their services. And it changes how much influence they have on the farms they work with.

The most successful crop consultants in California are not just great CCAs and PCAs. They run their consulting practices the same way a CEO runs a company. And honestly, that gap is getting bigger every year.

Technician Thinking vs. CEO Thinking

The traditional crop consultant model is pretty simple. You build a list of growers. You scout fields. You write recommendations. You help manage pests and nutrition. And you bill based on acres or visits.

It works. But it also creates a ceiling.

When you operate purely as a technician, your time becomes the limiting factor. There are only so many acres you can walk in a day. Only so many calls you can take. Only so many reports you can write. Eventually, your calendar fills up.

Consultants who think like CEOs look at their role a little differently. Instead of asking, "How many acres can I personally cover?" they start asking bigger questions:

How do I create more value for growers?

How do I focus on the decisions that really matter?

How do I build a consulting business that is not completely dependent on every hour of my time?

Those are CEO questions. And the consultants who ask those questions tend to build stronger, more respected consulting practices.

Running Your Consulting Practice Like a Business

One of the biggest shifts happens when a consultant starts treating their consulting practice like a real company. That means being intentional about growth.

A lot of consultants simply add acres every year. They take on new growers, get busier and just keep moving. But stepping back and looking at the business side can be a game changer.

Ask yourself a few simple questions:

What type of growers do I actually want to work with?

Where do I create the most value?

What crops fit my expertise best?

Which services really move the needle for my clients?

When consultants start thinking this way, something interesting usually happens. They realize they do not necessarily need more clients. They need the right clients.

The best consultants tend to work with growers who value their thinking, not just their recommendations. They become trusted advisors instead of simply the person writing the spray sheet. And that changes everything.

Think in Acres, Not Hours

Another thing great consultants do differently is how they measure their time. Technicians tend to think in hours. They measure their workload by how busy they are. CEOs measure impact.

In crop consulting, one of the easiest ways to think about impact is acres. Acres represent influence. Acres represent the scale of the decisions being made.

When you start thinking this way, the focus shifts from activity to value. Instead of asking, "How many hours did I work this week?" the question becomes something different: What acres did I influence this week?

Did you help a grower prevent a pest problem before it exploded? Did you guide a fertility program that could improve yield? Did you help a grower make a tough call during a difficult season?

Those decisions matter. Great consultants understand their job is not just walking fields. Their job is helping growers make better decisions across thousands of acres. And those decisions often happen in conversations, not just in the field.

Build Systems That Make Life Easier

One of the hardest parts of crop consulting is that the business is usually built around one person. One person holds the relationships. One person knows the fields. One person manages the schedule.

That works ... until it starts wearing you down.

Eventually, the calendar gets packed, the driving adds up, and the season starts feeling like a sprint that never ends.

Consultants who think like CEOs solve that problem by building systems. They create organized reporting methods so growers stay informed. They keep field notes organized so information is easy to access. They develop consistent ways to scout, report and communicate. Some consultants even build small teams to help manage workload.

None of this replaces the consultant. It simply removes some of the pressure so they can focus on the things that matter most: the key conversations with growers, the big decisions during the season, and the relationships that drive long-term trust.

When those things are dialed in, the consulting practice becomes much more manageable.

Becoming a Strategic Advisor

The consultants who think like CEOs tend to play a bigger role on the farm. They are not just scouts. They are advisors.

Growers rely on them to interpret research, evaluate new products and help navigate risk. They often sit right in the middle between growers, suppliers, researchers and applicators.

That position carries a lot of responsibility. But it also carries a lot of influence.

The consultants who reach that level are the ones who consistently bring value beyond the field visit. They stay curious about the industry. They keep learning. They pay attention to new pressures, technologies and strategies. They understand the business of agriculture, not just the agronomy. And growers notice that.

The Future of Crop Consulting

Agriculture is changing fast. Technology is evolving. Data is everywhere. Regulations continue to shift. And growers are being asked to make more complicated decisions every year.

That means the role of the crop consultant is becoming even more important. Growers need trusted advisors who can help them cut through the noise and make smart decisions.

But the consultants who will thrive in the future are the ones who evolve their mindset. They will still understand the science. They will still know the crops. But they will also run their consulting practice with intention, discipline and strategy.

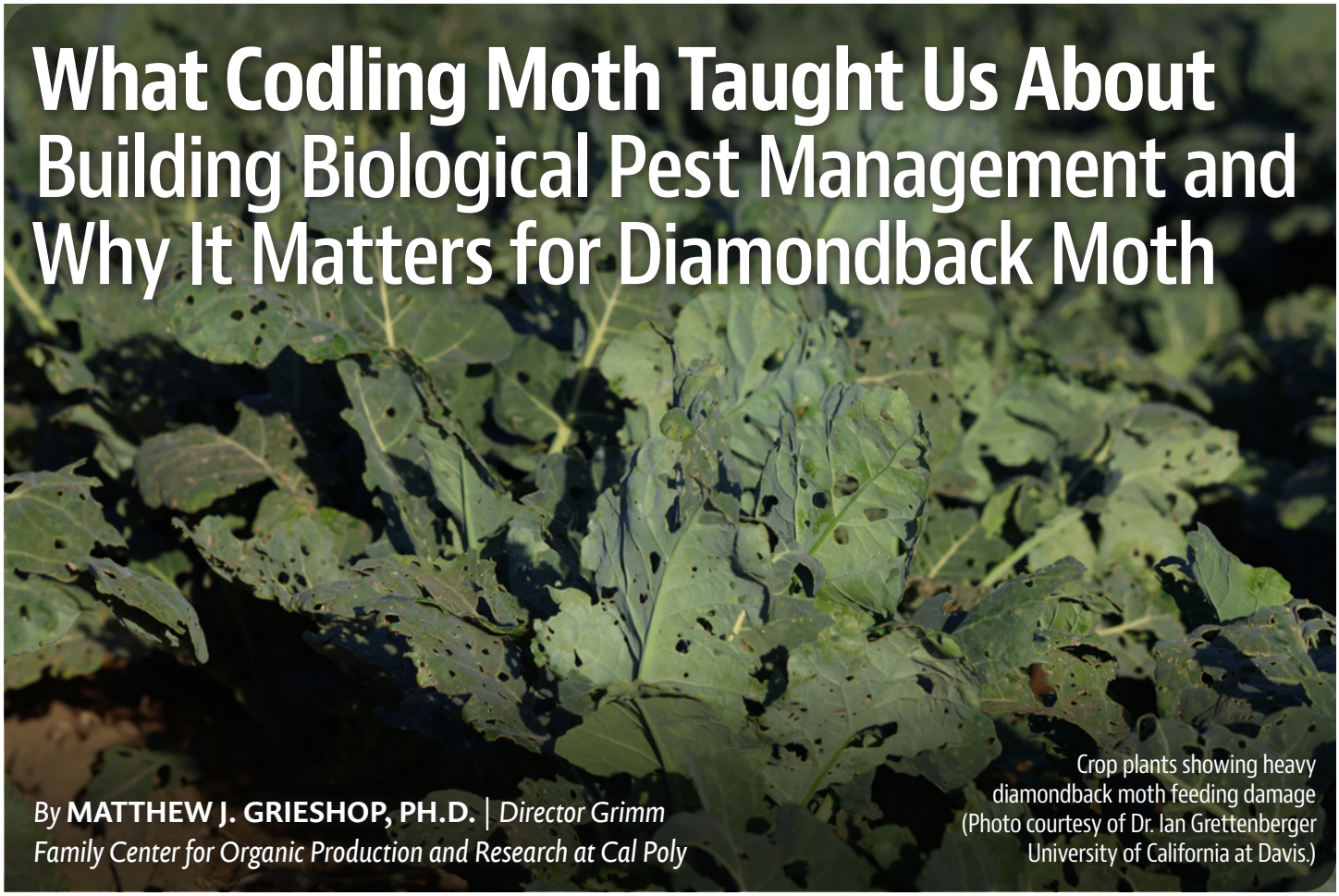
In other words, they will think like CEOs.

And when that happens, the consultant stops being just another service provider. They become one of the most valuable voices on the farm.

Comments about this article? We want to hear from you. Feel free to email us at article@jcsmarketinginc.com



What Codling Moth Taught Us About Building Biological Pest Management and Why It Matters for Diamondback Moth



By **MATTHEW J. GRIESHOP, PH.D.** | *Director Grimm Family Center for Organic Production and Research at Cal Poly*

Crop plants showing heavy diamondback moth feeding damage (Photo courtesy of Dr. Ian Grettenberger University of California at Davis.)

FOR PEST CONTROL ADVISORS WORKING in vegetable crops, few insects inspire as much frustration as diamondback moth (*Plutella xylostella*). Despite decades of insecticide development, this pest continues to evolve resistance, exploit production gaps, and resurge when control programs falter. As regulatory pressure increases and broad-spectrum options continue to erode, interest in the development of biological pest management (bioinsecticides, natural enemies, etc.) for this pest has grown. (**Fig. 1**)

Codling moth (*Cydia pomonella*) control in apples provides an amazing biological insect pest management success story. At first glance, application of this success story to diamondback moth may seem difficult. Codling moth is a tree fruit pest, diamondback moth attacks annual vegetable crops. And while their biology differs in important ways, codling moth remains one of the clearest examples of the investments needed to develop a durable, biologically based pest management system.

Why Codling Moth Is a Misleading "Easy Example"

Codling moth is often described as a biological management success story. What is frequently left out is how long it took to get there. Phenology models alone required decades of research. Mating disruption took nearly 50 years from concept to widespread adoption. Granulosis virus required 40 years of development before becoming operational at scale.

Bottom line: Biological pest management is slow because it is precise.

The central lesson from codling moth is not about a single tool or product. It is about process. Codling moth biological management did not emerge overnight. It was built slowly and deliberately. That history provides a realistic lens through which to evaluate what biological pest management for diamondback moth might look like, the scale of investment needed, and where advisors can play a critical role.

Two Very Different Ways to Manage Insects

For most of the twentieth century, pest management followed a broad-spectrum paradigm. Insecticides such as organophosphates, carbamates, and pyrethroids worked across many insect pests because they disrupted conserved physiological pathways, were residual contact-active, and had long residuals. Thus, one product could suppress multiple pests, often across several life stages. For managers, this meant fewer decisions, simpler timing, and predictable short-term results.

Diamondback moth fit well within this paradigm until it didn't. ➲

BASF
We create chemistry

Sefina®
Inscalis® Insecticide



When pests can't eat, they can't destroy.

With no pollinator restrictions, Sefina® insecticide starves pests while being gentle on pollinators.

Sefina insecticide has no pollinator restrictions and is not a restricted-use pesticide. Always read and follow label directions.

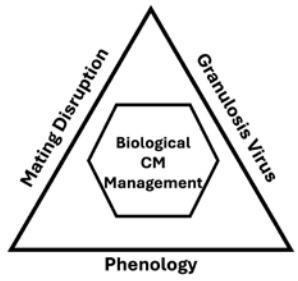
Inscalis and Sefina are registered trademarks of BASF. © 2025 BASF Agricultural Solutions US LLC. All rights reserved.

Take the "Protecting Pollinators" course for free at AgCEUOnline.com

Resistance to many if not most modes of action is now widespread globally (Zalucki et al. 2012; Furlong et al. 2013). The result has been increasing spray frequency, shrinking windows of efficacy, and rising production risk.

Broad-Spectrum vs. Biological Control: A Reality Check
Broad-spectrum insecticides work across many species because they ignore biological nuance. Biological systems must confront that nuance directly. That tradeoff explains why chemistry scales quickly and why biological systems endure once they are built.

Biological pest management represents a fundamentally different approach. Rather than suppressing pests through generalized toxicity, biological systems exploit species-specific vulnerabilities: phenology, mating behavior, host specialization, microbial susceptibility, and ecological interactions. This approach is slower to develop, harder to generalize, and far more knowledge intensive. The payoff, when successful, is durability.



Codling moth biological management triangle. Each side of the triangle interacts to create sustainable management (Photo courtesy of Dr. Matthew Grieshop Cal Poly San Luis Obispo.)

Codling moth illustrates this tradeoff better than almost any other agricultural insect pest.

Why Codling Moth Became a Biological Management Success

Codling moth (*Cydia pomonella*) is the most economically significant insect pest of apples. Its larvae feed internally within fruit, making damage severe and difficult to prevent. Historically, this biology forced growers to rely heavily on insecticides and precise spray timing.

These challenges drove an extraordinary research and extension effort. Because codling moth control failed so easily when mistimed, researchers were compelled to understand the insect in detail. Over decades, this work coalesced into a biological management system built around three interacting components (**Fig. 2**).

The Codling Moth Biological Management Triangle

1. Phenology as the management framework

2. Mating disruption as baseline population suppression

3. Granulosis virus as targeted larval control

No single component works reliably on its own. Together, they form a system that has enabled large-scale organic apple production and reduced insecticide reliance across conventional orchards (Jones et al. 2008; Witzgall et al. 2010).

Phenology: The Foundation That Came First

The first pillar of codling moth biological management is phenology, and it predates biological products by decades.

A 40-Year Head Start

Codling moth phenology research began in the 1930s, initially as descriptive life-history work documenting instars, seasonal flight patterns, and overwintering behavior (Shelford 1927; Glenn 1922). By the 1950s and 1960s, researchers recognized that codling moth development was tightly temperature-driven and synchronized with host fruit phenology.

This led to the development of degree-day models, with the first widely adopted codling moth degree-day model published in the early 1970s (Riedl et al. 1976). By the 1980s, these models were being disseminated through extension programs across North America.

Estimated investment:

- ~40 years of research (1930s–1970s)
- 15–25 university and government programs
- 50–100 core scientists
- Hundreds of graduate students and technicians
- Dozens of extension professionals

For advisors, phenology transformed codling moth management from calendar spraying to event-based decision-making. Eggs and neonates became management targets, not just "the season." (**Fig. 3**)

Mating Disruption: From Curiosity to Keystone Technology

Mating disruption, now considered the cornerstone of codling moth biological management, took decades to reach this status.

Mating Disruption Is Not a Rescue Treatment
Mating disruption does not kill insects. It prevents the next generation from being created. Expecting immediate population collapse from mating disruption alone leads to disappointment and misuse.

Its strength is cumulative suppression over time, especially when used area-wide.

The concept was first proposed in 1967, with early demonstrations in cabbage looper (Shorey and Gaston 1967). Codling moth pheromone chemistry was elucidated in 1971

during a period of rapid growth in chemical ecology (Roelofs et al. 1971).

Commercial adoption, however, lagged far behind discovery. Economical pheromone synthesis, dispenser development, and field-scale validation took time. Widespread adoption did not begin until the 1990s, and area-wide programs only became common after 2000 (Cardé and Minks 1995; Witzgall et al. 2010).

By 2015, approximately 90% of Washington apple acreage was under mating disruption (Washington Tree Fruit Research Commission data).

Estimated investment:

- ~45–50 years (1970s–2010s)
- 20–30 research programs
- 75–150 scientists
- Hundreds of graduate students and postdocs
- Significant private-sector R&D
- Continuous extension involvement

For managers, mating disruption requires a mindset shift. It is prophylactic, not curative. It prevents future populations rather than killing existing ones. Its benefits accumulate over time, especially when deployed across large contiguous areas. If the tactic is removed from a program, codling moth rebounds and within a few seasons can become a serious problem once more.

Granulosis Virus: Precision with Constraints

The third pillar of codling moth biological management is codling moth granulosis virus (CpGV).

The virus was first isolated in 1963 (Huber 1963). European registration followed in 1984, U.S. registration in 1995, and widespread adoption occurred only after 2005. Development was constrained by challenges in mass production, UV stability, and application strategy (Lacey et al. 2008). Advisors learned several hard lessons:

- CpGV must be ingested, so spray coverage is critical
- UV degradation limits residual activity
- Frequent low-rate applications outperform infrequent high-rate sprays
- Resistance can develop, but strain variation allows adaptation (Asser-Kaiser et al. 2007)

Estimated investment:

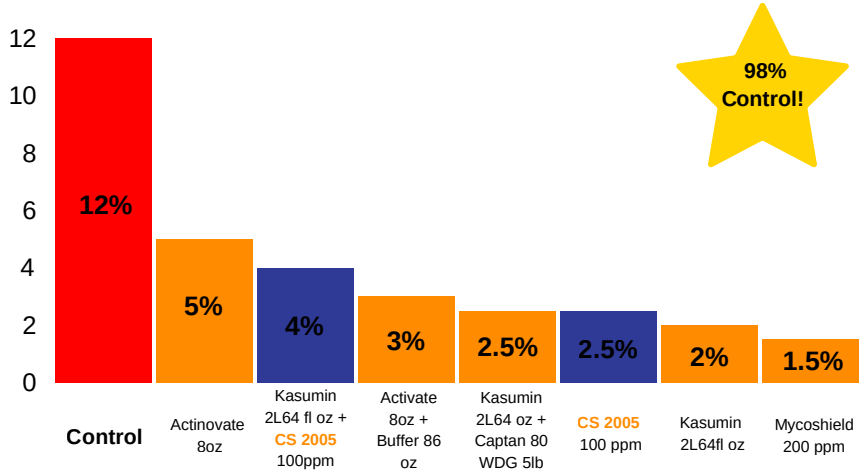
- ~40 years
- 15–20 research institutions
- 40–80 scientists
- Hundreds of graduate students and technicians ➲



Our copper sulfate pentahydrate in-solution formula is **OMRI-listed** with systemic capabilities! It's environmentally friendly by using less than an 1/8 lb per acre of metallic copper specifically designed to combat agricultural diseases in Cherries including: *Bacterial Blast, Bacterial Canker, Coryneum Blight, Blossom Brown Rot and Cherry Leaf Spot!*

Evaluation of Antibacterial Treatments for Protection of cv. Coral Cherry Fruit from Bacterial Blast

Dr. Jim Adaskaveg, Department of Plant Pathology, University of California, Riverside, CA 2014



Applications were done on 3-11-14 at 50% bloom using an airblast backpack sprayer at a rate of 100 gal/A. *Inoculated with copper-resistant strain* fruit were evaluated for the presence of blast symptoms in mid-April.

OMRI LISTED For Organic Use

For More Information on Research and Application Rates, Please Scan the QR Code or visit www.MagnaBon.com

Less Copper, More Power!

‘For diamondback moth, success is highly unlikely from a single new product.’

Why This Matters for Diamondback Moth

Diamondback moth (*Plutella xylostella*) presents a very different biological challenge, and different opportunities.

Why Diamondback Moth May Actually Be Easier — Eventually

Diamondback moth reproduces faster and attacks more hosts than codling moth. But unlike codling moth, it feeds externally and is exposed to parasitoids throughout development. When broad-spectrum insecticides are minimized, natural enemies can play a major role in suppression.

This is an opportunity we have never had in codling moth management.

Diamondback moth’s rapid generation time and continuous host availability complicate suppression. However, unlike codling moth, diamondback moth larvae are exposed throughout development, providing better opportunities for control using insecticides and natural enemies (**Fig. 4**). For example, parasitic wasps such as *Diadegma insulare* can exert substantial control when broad-spectrum insecticides are minimized (Talekar and Shelton 1993; Furlong et al. 2013) (**Fig. 5**).

Adapting the Triangle for Diamondback Moth

The codling moth triangle cannot be copied directly, but it can be adapted. (**Fig. 6**).

A Diamondback Moth Biological Management Triangle

1. Phenology and population modeling

2. Mating disruption for baseline suppression

KEY DIFFERENCES ADVISORS MUST CONSIDER

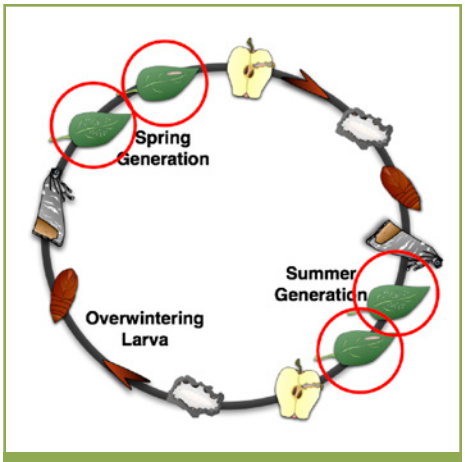
Trait	Codling Moth	Diamondback Moth
Feeding	Internal	External
Host range	Narrow	Broad
Generations/year	2–3	Many
Diapause	Obligate	Often absent
Natural enemies	Limited	Strong
Immigration	Low	High

3. Biological insecticides and natural enemy conservation

Fortunately, we already have phenological models for diamondback moth. Seminal work by Harcourt established temperature-dependent development rates, which were later refined into degree-day models used for timing scouting and interventions in pest management programs (Harcourt 1957; Shelton et al. 1983; Kfir 1997). Application of these models may be especially useful during early season plantings while landscape populations of DBM are building.

Sprayable mating disruption products exist for diamondback moth but require frequent application. Point source dispensers have been developed, but optimal release rates, point-source density, and treated areas remain open questions. Annual cropping systems may offer opportunities for mechanized deployment that tree fruit systems never had. For example, dispensers could be integrated into plug trays or deployed using existing robotic weeding platforms.

Microbial tools such as *Bacillus thuringiensis* remain effective but are vulnerable to resistance without system-level integration. More recently, efforts have been made to commercialize DBM-specific granulosis virus, but optimal rates and timings of applications are still under development. Two such products are Lepigen (registered with both CA DPR and EPA) and Plutex (lacks EPA registration at time of writing).



Two generation codling moth life cycle. Circles indicate stages vulnerable to in season insecticides (Image courtesy of Dr. Matthew Grieshop Cal Poly San Luis Obispo.)

The Big Lesson for Advisors

The most important lesson from codling moth is not about products. It is about expectations.

Codling moth biological management required:

- 70–90 years of cumulative research
- Dozens of institutions
- Thousands of people
- Continuous refinement

Biological pest management is built one insect at a time. Broad-spectrum chemistry hides biological complexity. Biological systems must confront it directly.

For diamondback moth, success is highly unlikely from a single new product. It will come from coordinated investment in phenology, behavior, microbial tools, and natural enemy conservation and from advisors willing to guide growers through a longer transition.

Looking Forward

Diamondback moth is unlikely to be "solved" quickly. The codling moth experience, however, shows that durable biological management is possible when the agricultural community commits to understanding an insect deeply enough to manage it predictably. Fortunately, we already have much of the baseline knowledge about the pest, and a variety of biological approaches exist, so a solution should not require 50 years of development. Instead, we can move directly to the integration phase of program development. Development of this program, however, will require a substantial investment in applied research and extension.

For PCAs and CCAs, this represents both a challenge and an opportunity. Those who understand the biology behind the tools will be best positioned to help growers navigate ➲



4th instar diamond back larva (inset) and adult moth. Image (not to scale) (Photo courtesy of Dr. Ian Grettenberger University of California at Davis.)







resistance, regulation, and the future of sustainable crop production.

Selected References

Asser-Kaiser, S., Fritsch, E., Undorf-Spahn, K., Kienzle, J., Eberle, K. E., Gund, N. A., Reineke, A., Zebitz, C. P. W., Heckel, D. G., and Jehle, J. A. 2007. Rapid emergence of baculovirus resistance in codling moth (*Cydia pomonella*). *Journal of Invertebrate Pathology* 95: 59–66.

Cardé, R. T., and Minks, A. K. 1995. Control of moth pests by mating disruption: successes and constraints. *Annual Review of Entomology* 40: 559–585.

Furlong, M. J., Wright, D. J., and Dosdall, L. M. 2013. Diamondback moth ecology and management: problems, progress, and prospects. *Annual Review of Entomology* 58: 517–541.

Harcourt, D. G. 1957. The development and use of life tables in the study of natural insect populations. *Canadian Journal of Zoology* 35: 343–378.

Jones, V. P., Brunner, J. F., Grove, G. G., Petit, B., Tangren, G. V., and Jones, W. E. 2008. Codling moth (*Cydia pomonella*) integrated pest management in apple orchards. *Pest Management Science* 64: 1157–1167.

Kfir, R. 1997. Biology and management of diamondback moth (*Plutella xylostella*). *Annual Review of Entomology* 42: 347–372.

Lacey, L. A., Thomson, D., Vincent, C., and Arthurs, S. P. 2008. Codling moth granulovirus: a comprehensive review. *Biological Control* 44: 221–238.

Roelofs, W. L., Comeau, A., Selle, R., and Riedl, H. 1971. Sex pheromone of the codling moth. *Nature* 233: 496–497.

Riedl, H., Croft, B. A., and Howitt, A. J. 1976. Forecasting codling moth phenology based on pheromone trap catches and physiological time models. *Environmental Entomology* 5: 121–127.

Shelton, A. M., Scriber, J. M., and Andow, D. A. 1983. Monitoring of

diamondback moth populations using pheromone traps and degree-day accumulations. *Journal of Economic Entomology* 76: 135–141.

Talekar, N. S., and Shelton, A. M. 1993. Biology, ecology, and management of the diamondback moth. *Annual Review of Entomology* 38: 275–301.

Witzgall, P., Stelinski, L., Gut, L., and Thomson, D. 2010. Codling moth management and chemical ecology. *Journal of Chemical Ecology* 36: 80–91.

Zalucki, M. P., Shabbir, A., Silva, R., Adamson, D., Shu-Sheng, L., and Furlong, M. J. 2012. Estimating the economic cost of diamondback moth resistance to insecticides in Australia. *Crop Protection* 38: 30–36.

Acknowledgements:
I would like to acknowledge the Grimm Family for providing financial support for article development.



Diadegma spp. Diamondback moth larval parasitoid (Photo courtesy of Dr. Ian Grettenberger University of California at Davis.)

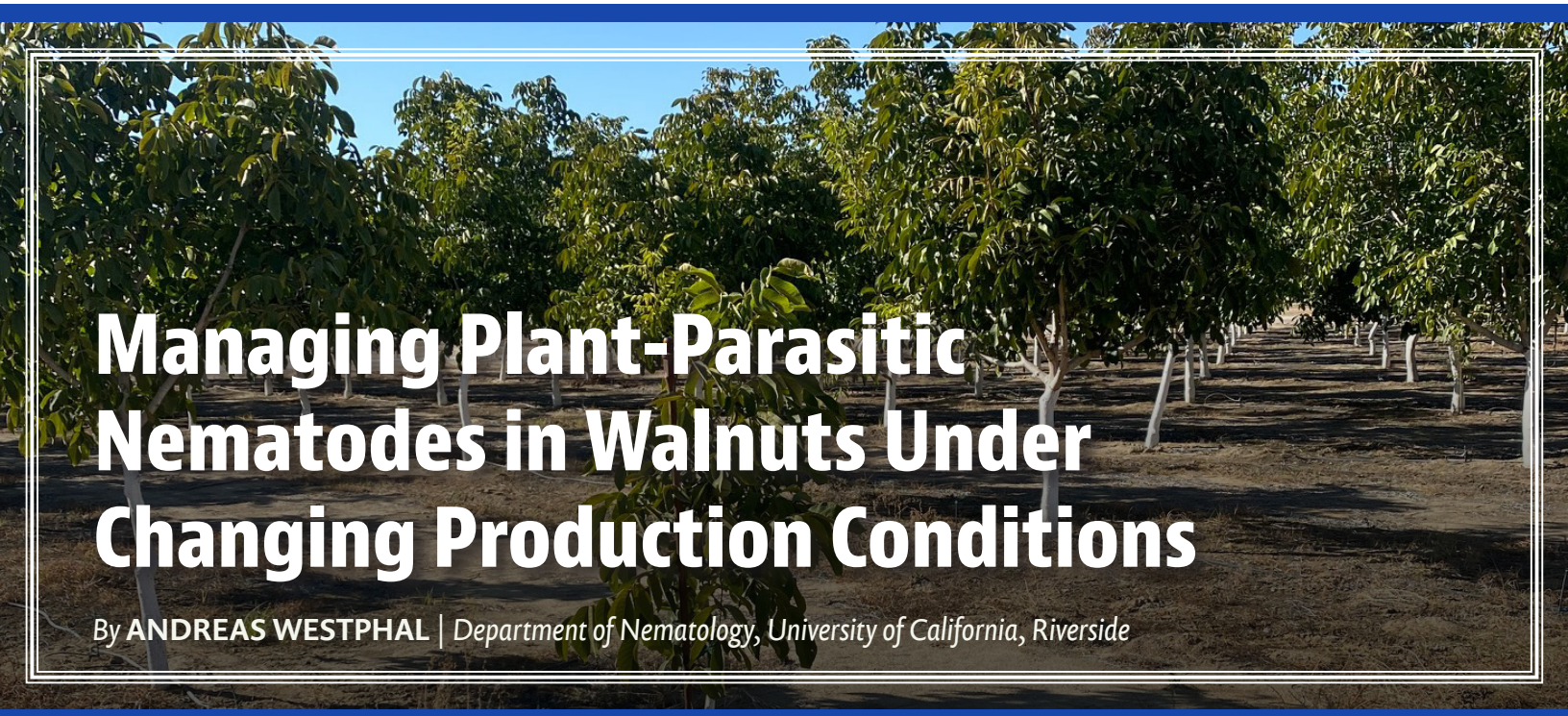
I would like to acknowledge Dr. Ian Grettenberger (University of California at Davis) for providing images for this article and both Dr. Grettenberger and Dr. Jeana Cadby (Western Growers) for input on the basic concepts presented.

Comments about this article? We want to hear from you. Feel free to email us at article@jcsmarketinginc.com

What Advisors Should Take Away

- Biological pest management is built one insect species at a time
- Codling moth biological management took 70–90 years to fully mature
- Expecting rapid biological solutions reflects chemical-era thinking
- Phenology is the backbone of all biological pest management systems
- Mating disruption is preventative, not curative
- Microbial insecticides require precision and repetition, not brute force
- Diamondback moth biology creates challenges but also unique opportunities
- Natural enemy conservation will be more important for diamondback moth than for codling moth
- Advisors play a critical role in helping growers reset expectations
- Long-term success depends on system design, not product selection





Managing Plant-Parasitic Nematodes in Walnuts Under Changing Production Conditions

By **ANDREAS WESTPHAL** | *Department of Nematology, University of California, Riverside*

Walnuts are sensitive to soil-borne pests and diseases, foremost plant-parasitic nematodes can damage new plantings already at low population densities (Photo courtesy Andreas Westphal.)

The California walnut industry goes through difficult times. In addition to market challenges, several production issues task the sustainability of walnut production. Quickly changing regulatory requirements modify the way walnuts can be grown. The Sustainable Groundwater Management Act (SGMA) makes production in southern parts of the valley problematic, and many orchards have been or are being removed. Another critical change in policy is the increasing stringency of regulations for application of 1,3-dichoropropene (1,3-D). This material has been widely used, often in co-applications with chloropicrin when walnut followed walnut, to reduce soil-borne diseases.

Regulatory Pressures and Soil Fumigation Challenges

Walnuts are produced on rootstocks more adopted to soil conditions than the scion cultivars would be. The long-term go-to rootstock was 'Paradox,' a cross of Northern California Black Walnut and English walnut. It is susceptible, among others, to root lesion nematodes, Phytophthora root and crown rot, crown gall, and the so-called replant disease. Preplant soil fumigation with 1,3-D has reduced the damaging effects, especially of root lesion nematodes, that can reduce plant growth at 1 nematode per 250 cc of soil at planting. The replant disease was mitigated by soil treatments with concomitant application of chloropicrin.

With the new regulations in effect since January 1, 2024, and January 1, 2026, soil moisture conditions have to be much higher than previously and are not conducive for sufficient 1,3-D gas movement through the soil to reach plant-parasitic nematodes. Requirements of deeper injection and the possibility of covering the soil by totally impermeable film (TIF) add expense to the process. The restriction to smaller field sizes that may be treated in a single day add to logistical challenges. In essence, soil fumigation with 1,3-D becomes much more expensive, less effective and more cumbersome to use.

Rootstocks and Biological Considerations

Soil fumigation practice is viewed as troublesome because large amounts of chemicals are used per acre. The Sustainable Pest Management Roadmap that aims at a reduction of synthetic pesticide use by 90% and for 90% of the farms to practice sustainably by 2050 further exacerbates the challenge to establish productive walnut orchards for coming generations. In essence, the production system needs a thorough overhaul. Among the soil-borne plant pathogens, the root lesion nematode is probably the most notorious. In surveys, it was found in 85% of the orchards tested. In addition to its low threshold level, it occurs at least 5 ft deep in soil and is difficult to reach by management tools. Using rootstocks that don't get damaged by this nematode has high sustainable appeal because these hypothetically "solve the problem for good." Root lesion nematode-tolerant rootstocks are commercially available.

'VX211' and 'Grizzly' are promoted for their medium to high levels of nematode tolerance. It is important to remember that these rootstocks are susceptible to nematode parasites but don't seem to suffer damage as much as others. While an enticing practical approach, biologically there are limitations of using nematode-tolerant rootstocks. It is not known how the high population densities that can develop under these rootstocks will interact with the trees in decades to come. There is also a lack of information how expansive this tolerance is.

For example, it appears that VX211 often can tolerate root lesion nematode but does get damaged when root-knot nematodes are feeding on its roots. This latter species is less in the growers' mind since pure English rootstocks (that are very susceptible and sensitive to this nematode) are seldom used anymore. In root lesion nematode, large population densities over time could create the possibility of selection of new "types" of this species. Perhaps, such nematodes could "learn" how to damage a tolerant rootstock. Because the current tolerant rootstocks allow for copious nematode reproduction, the risk for such shift in the nematode population appears real. After all, selection is a numbers game.

The more individuals are exposed to certain environmental queues, the higher the risk to encounter a new or different type of nematodes. Limiting nematode reproduction is liable to reduce these risks. While resistance has its own biological problems, broad resistance to root lesion nematode combined with tolerance is an important goal in rootstock development. These matters probably sound theoretical, but alertness of possible nematode population changes must not go ignored.

In a large cooperative effort of (molecular) breeders, engineers, plant scientists and plant pathologists (different UC campuses and USDA-ARS), farm advisors (UCANR), nurseries, and grower collaborators, a rootstock development program is in place. Graciously supported by the California Walnut Board and Commission, by CDFA, and the federal grantor NIFA, numerous rootstock trials are in place on commercial farms and on research stations. Out of these efforts, one rootstock, tentatively called 'K3,' expressed reduced susceptibility AND tolerance to root lesion and root-knot nematodes.

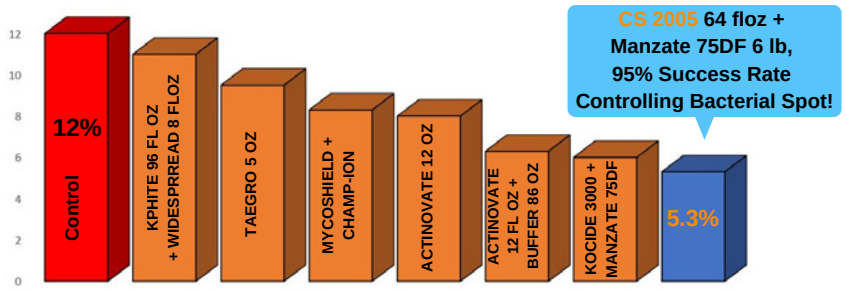
K3 performed well in regional rootstock trials in the Sacramento Valley. It also showed tolerance to the walnut replant disease when planted to non-treated root lesion nematode-infested walnut replant sites. This rootstock is nearing release for commercial use. In the said breeding and development program more rootstocks are expected to become available in the next few years. These rootstocks combine resistances to root lesion nematode, root-knot nematode, crown gall, and Phytophthora crown and root rot. These rootstocks are currently undergoing on-farm testing. Readers are invited to participate in testing of 'K3' and other rootstocks to get a first-hand look at the new technology as it nears release.

Alternatives to Fumigation and Future Directions

Developing rootstocks is a tedious process. Despite the high appeal of using such superior rootstocks, growers can't wait if they plan to replace walnut orchards. Comprehensive studies to identify possible alternatives to ➲



Our copper sulfate pentahydrate in-solution formula is **OMRI-listed** and offers systemic capabilities with proven results against copper-resistant disease strains. Environmentally friendly, it uses less than 1/4 lb of metallic copper per acre and is specifically designed to combat diseases in Almonds, including:
Bacterial Blast, Bacterial Spot, Bacterial Canker, Blossom Brown Rot, and Coryneum Blight!



OMRI LISTED For Organic Use

For More Information on Research and Application Rates, Scan the QR Code or Visit www.MagnaBon.com

Less Copper, More Power!

soil fumigation with 1,3-D have been ongoing for decades. In recent years, new chemistries have become available that were perceived to have potential as pre-plant soil treatments. These are so-called "non-fumigant nematicides."

In contrast to 1,3-D, these chemicals cannot redistribute in the soil environment after application. They need to be delivered to the target sites in the soil profile. Such delivery can be done with copious amounts of drench water that wets the soil profile 5 ft deep. Approximately six inches of water are necessary to accomplish this delivery. Such treatment requires complex irrigation systems and capabilities to inject the chemical into the irrigation stream.

Fascinatingly, several of the non-fumigant chemicals had efficacy in reducing nematode numbers in the soil profile at just a few pounds of active ingredient per acre compared to the several hundred pounds of 1,3-D necessary. But in addition to the application challenges, the level of efficacy of these materials was insufficient for a stand-alone preplant treatment. Only the (bio-) fumigant Dominus (AITC-containing material) was effective in reducing nematode numbers throughout the soil profile when delivered with irrigation water to the target sites. Simplified application methods had been developed. But high amounts per acre (40-80 GPA) of this material were necessary for efficacy, rendering it a poor fit for SPM. In addition, volatile organic compound regulation may encumber its registration.

The biorational method of anaerobic soil disinfestation (ASD) showed more promise for acceptability concerning air quality regulations and other human health concerns. In this method, easily decomposable organic matter is spread on the soil surface, incorporated, drip irrigation lines and totally impermeable film (TIF) installed, and the soil kept moisture-saturated for about one month. With the proper amount of substrate, preferably rice bran, and the correct irrigation schedule, this method is highly effective in reducing plant-parasitic nematodes and the replant disease from soil.

Key challenge is its expense and the excessive amount of plastic necessary for this procedure. This method requires copious amounts of drench water and is well-suited for flat level ground but probably would be difficult to use in hilly fields. Research work is ongoing to reduce application expenses by methods that eliminate the need for plastic cover and drip irrigation lines. Also, use of alternative substrates is investigated. Root lesion nematode-resistant cover crops are cropped during the fallow period between orchard cultivation.

In late summer, biomass produced by such crops is then macerated and incorporated in the soil as substrate for ASD. This may further reduce the expense of this method and make it better locally adoptable. Here, another offer to growers who plan to plant a new walnut orchard in the near future. The author of this article is on standby to test these new ASD tools on commercial farms. Growers interested in seeing these procedures first-hand and learning how to implement them on their farms are encouraged to reach out to the author.

'Using tolerant rootstocks alone may not be enough, as high nematode populations can still pose long-term risks to orchard health.'

Post-Plant Management and Orchard Recovery

Efforts invested in testing post-plant remedies for existing walnut orchards confirmed that Movento applications following the original protocol developed by Dr. Mike McKenry offered yield protection. Of other post-plant tools, Salibro was the most effective in reducing population densities of root lesion nematodes. Currently, this material is registered for non-bearing orchards only. In essence, it is only useful to establish a new orchard, but for bearing years it cannot be used until the registration is encompassing that use as well.

At the current time of reduced planting, growers may wonder if extended fallow periods or "crop rotation" rid their soils of the soil-borne plant pathogens that can create so much trouble. While there is some alleviation of the soil-borne pest and disease problems, extended fallow is typically not sufficient to forego any type of corrective action before planting a new orchard. For example, an over-the-thumb rule is that the replant disease in a fallow field after walnut orchard removal declines by 50% per year, meaning from 50%, 25%, 12.5% and so forth. So, some alleviation will come from patience.

Root lesion nematodes will also decline, but their very low threshold level coupled with their high reproductive capacity can make them resurge quickly. "Rotating" to other crops has limited value. Almond, stone fruit, and pistachio all host root lesion nematode and will be damaged by it.

So in summary, sustainable production of walnut remains challenging under the new conditions. There is hope on having new and improved rootstocks available that will reduce the negative impacts of soil-borne pathogens on walnut within the next few years. Until then, soil treatment options are being developed that carry the potential to partially replace chemical soil preplant fumigation. These methods become more affordable and are set to compete with the ever more cumbersome and costly chemical treatments.

Research never stops, so additional tools are being tested and developed. It is the nature of perennial crops that developing additional alternatives will take time. Progressive and curious growers are encouraged to participate in on-farm studies to support the quick adoption and implementation of technologies available now. The researchers "can't do it without you."

Comments about this article? We want to hear from you. Feel free to email us at article@jcsmarketinginc.com

Crop Consultant

CONFERENCE

September 23-24, 2026

HOSTED BY:
Progressive Crop Consultant

IN THE HEART OF CALIFORNIA!

Visalia Convention Center
303 E Acequia Ave, Visalia, CA 93291

REGISTER NOW, UNLOCK CEU!

EARLY ACCESS TO CEU COURSES EACH MONTH



REGISTER NOW
www.progressivecrop.com/CCC

Why wait until September to get CEUs?

Register for the Crop Consultant Conference 2026 now, and unlock exclusive early access CEUs before the event!



Reduced Fertilizer Application Rates Demonstrate Measurable Returns in CALIFORNIA ALMOND PRODUCTION

By **DYLAN ROGERS** | *Account Manager, AgroLiquid*

Almonds swept and windrowed, ready for harvest (Photos courtesy AgroLiquid)

CAN ALMOND GROWERS REDUCE fertilizer application rates without sacrificing yields? That's the question many are asking as they navigate rising input costs, tightening water allocations and increasing pressure to demonstrate sustainable practices. But the challenge goes beyond reducing application rates, it's determining whether nutrient formulation, availability and uptake efficiency matter more than total volume applied.

Seven years of field research in California's Central Valley examined this question through controlled trials comparing conventional and reduced-rate fertility programs.

Why Nutrient Formulation Matters in Almond Production

Potassium and phosphorus represent critical nutrients for almonds throughout the growing season. Deficiencies limit plant growth and yield, but overapplication creates its own problems. Excess potassium can leave behind residual salts and chlorides, damaging soil health and tying up nutrients, while too much phosphorus can tie up zinc and other nutrients. Delivering the right amount of nutrition at the right time is key to a successful growing season.

Trial Design and Methodology

To understand whether growers could obtain the same yield with lower application rates, AgroLiquid worked with Bisabri Research to conduct two multiyear almond trials in Westley, California. The trials, which ran from 2018 to 2021 and from 2022 to 2024, compared almond yield and return on investment (ROI) between the grower standard and high-efficiency liquid potassium and phosphorus products.

The initial trial, conducted from 2018 to 2021, tested 10-34-0 and potassium thiosulfate (45 gallons per acre each) against liquid phosphorus (18 gallons per acre) and potassium (15.2 gallons per acre).

The second set of data, collected from 2022 to 2024, focused on evaluating different potassium-based

Yield + ROI Comparison (2018-2021)			
Treatment	**Application Rate** (gal/acre)	**Yield** (lbs/acre)	**Net Benefit** ($/acre)
10-34-0 + potassium thiosulfate	45+45	2,788	Baseline
Kalibrate® + PrG®	18+15.2	2,940	+$416

Table 1

Yield + ROI Comparison (2022-2024)			
Treatment	**Application Rate** (gal/acre)	**Yield** (lbs/acre)	**Net Benefit** ($/acre)
Potassium thiosulfate	45	2,625	Baseline
0-0-23-8S	52	2,698	+$151
Potassium acetate	33.75	2,729	+$141.88
Kalibrate®	15.2	2,750	+$369.77

Table 2

treatments against a potassium thiosulfate control. This trial included four distinct treatments:

- Potassium thiosulfate (45 gallons per acre)
- 0-0-23-8S (52 gallons per acre)
- Potassium acetate (33.75 gallons per acre)
- Liquid potassium (15.2 gallons per acre)

How Reduced-rate Applications Impacted Yields

Results showed consistent patterns across both trial periods:

- In the 2018–21 trial, the reduced-rate combination improved yields by 152 pounds per acre over the grower standard.

Calcium Phosphite For Nuts.



PHOS★★★PRO®
CALCIUM
0-16*-0
GUARANTEED ANALYSIS
Total Phosphoric Acid (P_2O_5)..... 16.00% Calcium (Ca) 4.00%
(AOAC Method 960.02) Drived from Calcium Phosphite)



PHOS-PRO Calcium Provides Immediate Uptake Of Phosphorus and Calcium For Nut Set And Growth.



- Calcium for nut quality
- Acidic tank mix buffer formualtion
- Excellent tank mix synergist with biostimulants and PGR products
- Flexible application by ground or air, prebloom, bloom, nut sizing and post harvest
- Excellent value for your nut crop!



GROW MORE®

For More Information:
Call GROW MORE: 800 338 7160 or Visit Us At: www.growmore.com



Bisabri Research field staff harvesting and recording weights for each trial replication

• In the 2022–24 trial, the liquid potassium program delivered the highest yield, achieving 2,750 pounds per acre with only 15.2 total gallons applied, compared to 2,625 pounds per acre from the 45-gallon potassium thiosulfate control.

These findings demonstrate that customized nutrient plans, built upon complete soil analysis reviewed by expert agronomists, can lead to measurable differences in nut production, resulting in higher yields and improved ROI for almond growers.

The Economic Returns of Reduced-rate Programs

Both reduced-rate programs generated higher returns through increased production — $416 and $369.77 per acre, respectively — based on a $2.50 per pound almond value. These figures reflect only direct yield value and do not account for potential operational savings from reduced application volumes, including lower labor costs and decreased fuel consumption.

'Trials showed an average 124-pound per acre yield advantage for the reduced-rate program, despite application volumes that were consistently 46 percent lower.'

Crop Nutrition Considerations for Growers

The research establishes three critical principles growers should consider when building a nutrient management program:

1. Formulation matters as much as rate. Nutrient form and delivery method influence how much nutrition reaches the plant. In alkaline Central Valley soils, formulations that minimize phosphorus fixation and potassium binding deliver more available nutrition at lower application rates.

2. Soil chemistry drives program design. Using soil tests to understand pH, cation exchange capacity and existing nutrient levels helps determine which products will perform most efficiently in specific conditions.

3. Economic returns don't correlate with application volume. Across seven years, trials showed an average 124-pound per acre yield advantage for the reduced-rate program, despite application volumes that were consistently 46 % lower than conventional programs.

What These Results Mean for California Almond Growers

The trial results remained consistent over the seven-year research period across varying market conditions and growing seasons, suggesting the principles apply broadly across California almond production regions with similar soil chemistry.

For growers facing pressure to reduce input costs while maintaining productivity, the research indicates that nutrient availability and formulation chemistry warrant equal consideration to total application rates when designing fertility programs.

Comments about this article? We want to hear from you. Feel free to email us at article@jcsmarketinginc.com

Almond Day

Built for growers and consultants focused on what's actually impacting almonds right now.

For more info, visit: **MyAgLife.com/events**

SCAN TO REGISTER

Pistachio DAY

A high-level pre-harvest meeting for growers and consultants serious about improving performance and making smarter decisions into harvest.

For more info, visit: **MyAgLife.com/events**

SCAN TO REGISTER

TURGOR

Dr. Muhammad Ismail Siddiqui, *Director R&D Product Innovations, AgroPlantae*

Why Stress Tolerance Is Decided Before Stress Ever Occurs

A physiology framework for understanding water use efficiency and crop resilience

In recent seasons, many growers and consultants have encountered a familiar frustration. Crops appear well managed. Irrigation schedules are followed. Fertility programs are sound. Yet when heat or water stress arrives, performance still declines. The typical response is to adjust irrigation, add nutrition or apply stress-mitigation products later in the season. Too often, these interventions arrive after the crop has already lost ground.

From a plant physiology standpoint, this outcome is not surprising. Crop failure under stress is rarely caused by a sudden absence of water or nutrients. More often, it reflects a limitation established much earlier, when the plant was still building its tissues.

Early Growth Is a Construction Phase

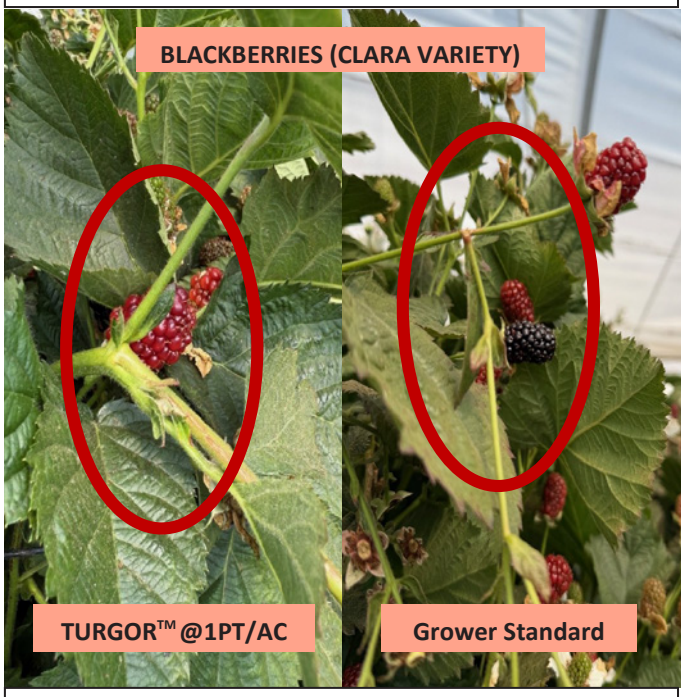
Early vegetative growth is often described in terms of canopy expansion, but physiologically it represents a **construction phase**. During this period, plants are not simply growing; they are building the structures they will rely on for the remainder of the season. Key processes occurring early include cell division, tissue patterning, formation of cell walls and membranes, development of vascular pathways and establishment of cuticle and epidermal layers.

Together, these processes define the **structural and functional capacity** of the crop. Once this phase concludes, cell number and tissue architecture are largely fixed. Later growth does not rebuild these structures; it only expands and utilizes what was already constructed. This distinction-capacity establishment versus capacity utilization is central to understanding stress responses.

Why Crops Collapse Under Stress

When heat or limited water availability occurs, the first physiological failure is not yield loss. It is the loss of turgor pressure, the internal water pressure that keeps cells firm, stomata functional and transpiration-based cooling active.

REDUCE STEM BREAKAGE WITH TURGOR™



50% less Stem Breakage with TURGOR

Turgor loss occurs when cell walls deform, membranes become unstable, non-stomatal water loss increases and internal water balance can no longer be regulated. These failures are structural in nature and depend less on how much water is applied at that moment and more on how well the tissue was built earlier. Once turgor declines, leaf temperature rises, photosynthesis slows and yield potential begins to erode, often before visible wilting appears.

Stress does not reduce yield by itself, it exposes how well the crop was built before stress ever occurred.

Structural Support as a Stress Strategy

This framework helps explain why late-season stress programs often produce inconsistent results.

While nutrition and irrigation remain essential, they cannot retroactively strengthen tissue that was constructed under suboptimal conditions. In contrast, practices and inputs that support early tissue construction and metabolic efficiency can raise the threshold at which stress causes physiological failure. From a physiological perspective, early growth depends on the coordinated availability of essential nutrients, water & environmental conditions, three components are particularly relevant during early growth:

- **Calcium,** which stabilizes cell walls and membranes by cross-linking pectins.
- **Silicon,** which is absorbed in plant-available form and deposited irreversibly as amorphous silica in cell walls and epidermal tissues.
- **Amino acid–based inputs,** which reduce the metabolic cost of building proteins and structural components during periods of high demand.

When present during tissue formation, these components support stronger, more resilient cells without forcing excessive or fragile growth.

Water Use Efficiency Starts Inside the Plant

In California production systems, water use efficiency is often framed in terms of irrigation scheduling and infrastructure. While these factors matter, they do not fully explain why crops receiving similar water inputs can perform very differently under stress. Physiologically, water use efficiency depends on membrane integrity, cell wall strength, the ability to retain turgor and efficient transpiration and leaf cooling. Improving water use efficiency therefore means improving how effectively plants use the water they receive, not simply reducing water applied.

A Practical Implication for Consultants

This physiology-based perspective suggests a shift in emphasis. Rather than relying primarily on reactive stress mitigation, greater attention should be given to **early-season structural preparation that aligns both material supply and metabolic capacity.** This makes early vegetative timing one of the most consequential decision points of the season, especially when crops are likely to face heat, water or combined environmental stress later on. While calcium and silicon-based products are widely available, structural reinforcement during early growth is not determined by mineral availability alone. Cell wall strengthening and silicon deposition are energy-dependent processes occurring during active cell division. If metabolic demand exceeds the plant's capacity, structural inputs may be applied but not fully integrated.

Approaches that combine calcium and plant-available silicon with substantial amino acid–based metabolic support are therefore better aligned with early vegetative physiology. Amino acids reduce the ATP cost of rapid tissue construction, allowing structural materials to be incorporated more efficiently.

TURGOR is a foliar-applied liquid biostimulant designed for early vegetative use that functions as a capacity-setting tool by integrating the physiological requirements for tissue construction, metabolic efficiency and internal water handling during early growth. By reducing the metabolic cost of building and stabilizing new tissue, this coordinated support helps determine how much stress a crop can withstand before physiological function begins to fail.

Final Perspective

Stress does not determine crop performance on its own. It reveals how well the crop was built to handle it.

Early cell division and tissue construction establish the structural and functional capacity of the plant. Later growth determines how fully that capacity is expressed.

Understanding this distinction helps consultants and growers make more informed decisions about timing, expectations and the role of early-season interventions in protecting season-long performance.

Visit AGROPLANTAE.COM or give us a call (559) 498-0388 to learn more



Figure 1. Trees at the Westside Research and Extension Center in December 2023, at the end of the first year of growth (Photo P. Gordon)



Figure 2. Leaf burn on 1st leaf pistachio trees, likely due to overapplication of nitrogen. (Photo P. Gordon)

NITROGEN AND PHOSPHORUS

Fertilization of Pistachios in the First Two Years

By **PHOEBE GORDON** | *Orchard Systems Advisor for Madera and Merced Counties; University of California Cooperative Extension*

PLANTING AN ORCHARD REQUIRES A LOT of work to ensure that the trees get off to the best start possible: picking the right rootstock and scion, prepping the ground and choosing the best irrigation system are just some of the decisions that need to be made. And of course, once the trees are in the ground, they need to be cared for so that they expand their canopies as fast as possible. While irrigation is the most critical part of establishing newly planted orchards, ensuring adequate nutrient availability without overfertilizing the trees is important, too.

I was first spurred to do this research when I realized that existing nonbearing pistachio tree fertilization guidelines were based on educated guesses, rather than research. Additionally, I, along with Greg Browne at the USDA, recently found that newly planted almonds grow more with some phosphorus fertilizer provided at planting. Could pistachios benefit from phosphorus, too?

Experimental Design and Sites

I established three different experimental locations to examine both nitrogen and phosphorus fertilization rates. The first orchard was at the Westside Research and Extension Center near Five Points, California, using nursery grafted Golden Hills on UCBI and planted in April 2023 (**Fig. 1**). The soil is a clay loam and has a soil organic matter level of 2.15% in the top foot of soil. Soil phosphorus levels are very low, less than 5 ppm, and nitrogen levels in the irrigation water are negligible.

This plot was designed as the testing ground. As it was unclear how much nitrogen nonbearing trees needed, nor was it clear whether their needs would change as the trees aged, I divided the plot into several sections; only Sections 1 and 2 will be discussed in this article. After testing rates at this site, I then moved into commercial orchards in later years to confirm the results. Thus, there are four plots to keep track of in this article. Table 1 is an overview of the location and years the plots were monitored.

The trial began in WREC Section 1 in 2023, though I did apply some phosphorus fertilizer to a few plots in Section 2 to test out two years of phosphorus fertilization rates. Trees in Section 2 got 2 oz. of nitrogen per tree, as that was the hypothesized need for trees of that age. This gave me the flexibility to see if nitrogen rates changed as the trees aged by ensuring that previous years fertilization practices would not affect the current year's. For instance, what if a 1st leaf tree needed very little nitrogen, but a 3rd leaf tree needed quite a bit? If I gave each treatment the same rate every year, this might not become apparent. Once a site was formally incorporated into the trial, those trees received the same rate throughout the rest of the trial. The nitrogen and phosphorus rates used can be found in **Table 2**.

Fertilizer Application Methods

Nitrogen was applied as urea in 2023 and 2025, and ammonium sulfate in 2024. The fertilizer was inserted into the ground in the wetted zone of a drip emitter to ensure that the nitrogen would not volatilize and that it would be accessible for uptake. Additionally, applying the fertilizer in these forms reduced the chance that nitrogen would be leached out of the root zone. While urea is technically mobile in soils, it is converted to ammonium fairly quickly when soils are warm. I saw some fertilizer burn when we applied 1/4 oz. of N weekly to first leaf trees (**Fig. 2**) and reduced

Trial location	1st leaf	2nd leaf
WREC Section 1	Treatments implemented, See Table 2	Same rates as 1st leaf
WREC Section 2	2 oz N/tree	Treatments implemented, See Table 2
Merced 1 and Merced 2	Treatments implemented, See Table 2	Same rates as 1st leaf

Table 1.

Treatment	WREC Section 1 (2023-2024)		WREC Section 2 (2024)		Merced 1 (2024-2025)		Merced 1 (2024-2025)	
	Oz N	Oz P2O5	Oz N	Oz P2O5	Oz N	Oz P2O5	Oz N	Oz P2O5
1N	0.5	0	0	0	0	0	0	0
2N	1	0	0.5	0	0.5	0	0.5	0
3N1P	2	3 oz (2023)	1	3 oz (2023)	NA	NA	1	3 oz (2024)
3N2P	2	6 oz (2023)	1	6 oz (2023)	1	6 oz (2024)	1	6 oz (2024)
3N0P	2	0	1	0	1	0	1	0
4N	4	0	2	0	2	0	2	0
3N1P, 2 years	2	3 oz (2023) 3 oz (2024)	1	3 oz (2023) 3 oz (2024)	NA	NA	NA	NA
3N2P, 2 years	2	6 oz (2023) 6 oz (2024)	1	6 oz (2023) 6 oz (2024)	1	6 oz (2024) 6 oz (2025)	NA	NA

Table 2.

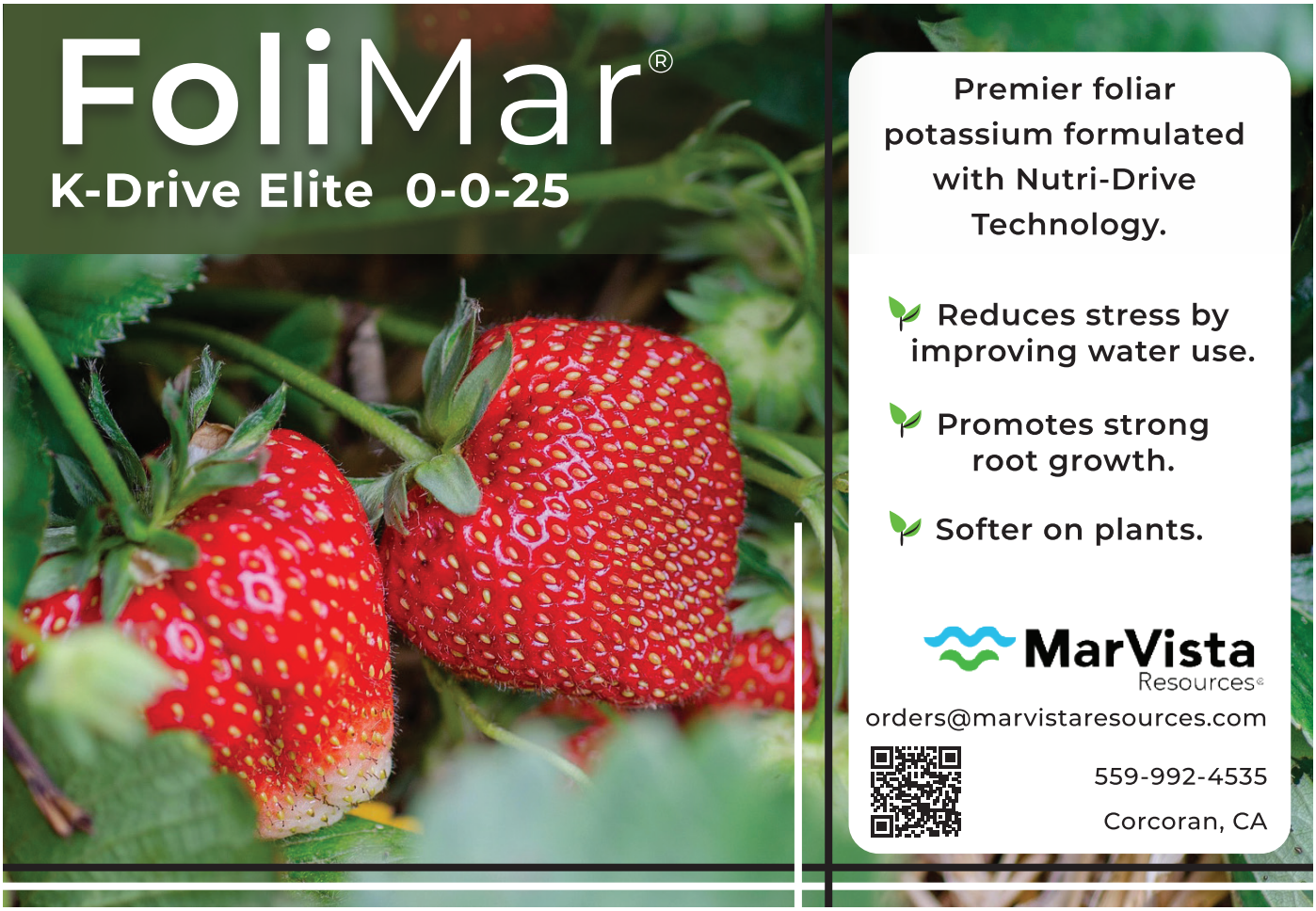
the weekly application rate to 1/8 oz. N at the follow-up research plots and no more leaf burn was observed. 2nd leaf trees did just fine with weekly application rates of 1/4 oz. N/tree.

Table 2: Nitrogen and phosphorus fertilization rates at the Westside Research and Extension Center, WREC, and Merced locations. The WREC location was planted in 2023. The Merced locations were both planted in 2024.

Phosphorus was applied as triple superphosphate. While this form of phosphorus is not used much in the industry, I wanted to make sure that we were only applying a straight phosphorus product. The phosphorus was applied about a month before leafout, buried in the soil about a foot from the tree.

At all sites, I included buffer trees between each experimental plot to ensure that trees from one treatment would not be picking up fertilizer from a nearby treatment. These buffer trees received 1/2 oz. of N/tree at WREC Section 1 in 2023, but after that, buffer trees were always unfertilized.

We used the caliper of the rootstock to monitor tree vigor and collected July leaf tissue values. Soil samples were



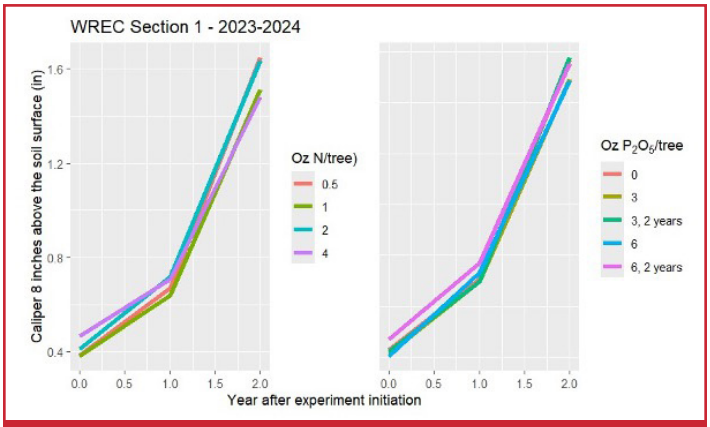


Figure 3. Tree response to nitrogen fertilizer applications (left) and phosphorus fertilizations (right) at the Westside Research and Extension Center. Trees were planted in April 2023, and treatments were applied in 2023 and 2024. No significant differences between treatments were found in either year.



Figure 4. The newly planted Merced 1 orchard, breaking from dormancy in April 2024. (Photo P. Gordon)

collected each fall to see if residual nitrogen was being left in the root zone after the growing season.

Results From WREC

There was no response to fertilizer growth at the Section 1 WREC plot in its 1st leaf (**Figure 2**). While leaf tissue values showed no response to nitrogen fertilizer, leaf phosphorus levels did increase with phosphorus fertilization, though it was inconsistent (data not shown). These differences disappeared in year 2, and I did not see any differences in leaf tissue concentrations at any other site in any other year.

Merced Expansion Sites and Findings

Due to the lack of response to fertilizer in WREC Section 1, I changed the rates applied to 1st leaf trees for my two expansion sites in commercial orchards in Merced County (**Table 2**). The lowest rate was now going to be 0 oz. of nitrogen per tree. I used the same rates in WREC Section 2, but kept the original rates in WREC Section 1 (**Tables 1, 2**).

Both Merced sites are on loamy soil, and both had a previous almond orchard chipped and incorporated into the soil. Merced 1, a nursery-grafted Lost Hills orchard on UCBI, was planted in February 2024 (**Fig. 4**), and Merced 2, a Golden Hills orchard on UCBI, also nursery grafted, was planted in April 2024. Organic matter levels there were higher due to the wood chips. My team did their best to remove the chips but it was difficult. 3.0% and 2.3% at Merced 1 and Merced 2, respectively. Compost was incorporated before planting at Merced 1 and no compost was applied at Merced 2. The growers shut off lines before any fertigation events to ensure that the experimental trees were not fertilized.

There was no response to nitrogen fertilizer at either of the Merced locations in either the first or second year of applications (**Figs. 5, 6**), nor was there a response to treatments at WREC Section 2 (data not shown due to space constraints).

Why has there been no response to either nitrogen or phosphorus fertilizer? Let's address phosphorus first: with the exception of recently published research on 1st leaf almond trees, all available evidence pointed to orchard trees rarely responding to phosphorus fertilizer. So, if the established knowledge is that trees just do not need much, if any, phosphorus, then this trial in pistachios actually goes along with conventional wisdom, not against it.

What about nitrogen? That finding was much more surprising. All trees, even those that received no nitrogen, had excellent vigor, so I knew that there was not something stunting their growth. There were three possible explanations I could think of.

First: were tree roots expanding into neighboring root systems, either within a row or between rows? My team partially excavated some root systems in early 2025 at WREC and found no evidence for this. Additionally, I included buffer trees between each plot within a row to further reduce this chance.

What about nitrogen mineralized from soil organic matter? This is likely, especially at the WREC location. The innate fertility of all three sites was high: despite the farm managers' valiant efforts, weeds were difficult to keep down in the first leaf. While this is partly due to limited herbicide options in 1st leaf orchards and no PRE herbicides, the vigorous weed growth is notable in the Merced locations as these sites had incorporated wood chips. Previous research into whole orchard recycling showed that weed growth is often suppressed in the 1st leaf, probably due to nitrogen starvation. This indicates to me that there is likely nitrogen available in the soil at my research plots.

The last likely explanation is that pistachios just do not need as much nitrogen as almonds, the only other nonbearing tree with research-backed nitrogen fertilization rates. While this can only be formally determined by cutting down some 1st leaf almond and pistachio trees and weighing them, it is easily observed that pistachio trees just do not develop their canopies as much as almonds in the 1st leaf. To add to this, our soil samples indicated that much of the nitrogen that was applied to the trees in the higher fertilization rates was being left in the soil (data not shown). The trees did not need it, so they were not taking it up.

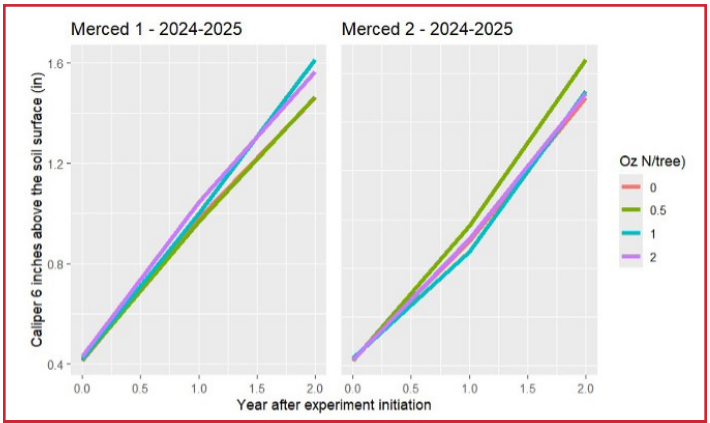


Figure 5. Tree response to nitrogen fertilizer applications at Merced 1, left, and Merced 2, right. Trees were planted early 2024, and treatments were applied in 2024 and 2025. No significant differences between treatments were found in either year.

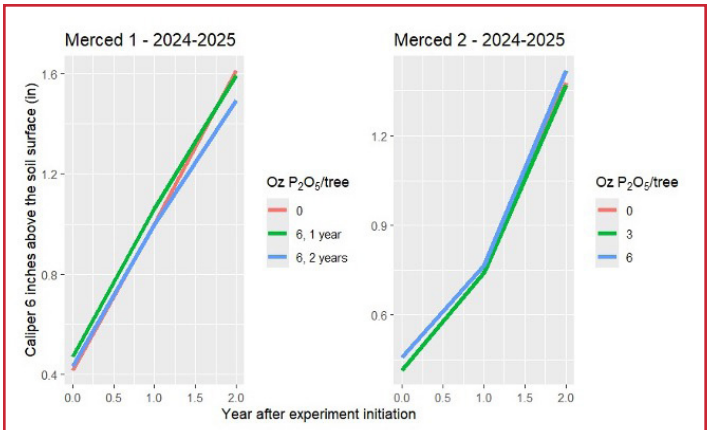


Figure 6. Tree response to phosphorus fertilizer applications at Merced 1, left, and Merced 2, right. Trees were planted early 2024, and treatments were applied in 2024, both Merced locations, and 2025, Merced 1 only. No significant differences between treatments were found in either year.

To sum up: at three different trial locations managed by different farm managers, 1st and 2nd leaf pistachio trees do not appear to need any nitrogen or phosphorus fertilizer. It is possible that trees growing in extremely sandy locations with low soil organic matter could respond to nitrogen fertilizer.

Acknowledgments: This research was primarily funded by the California Pistachio Research Board, with some salary support from a USDA NIFA grant. The trees planted at WREC were donated by Duarte Nursery, and Jeb Headrick provided the tree stakes. Richard Saldate, Gagan Gade, Baudelio Perez, Kelsey Leyva and Rito Medina helped make this research possible.

Comments about this article? We want to hear from you. Feel free to email us at article@jcsmarketinginc.com



Limitations of Soil Applied Biologicals for Lettuce Fusarium Wilt Management

By **EVAN TAMAYO** | *MS Student, Plant Protection Science, Cal Poly San Luis Obispo*
JOSUE DIAZ | *Lab Manager, Betteravia Farms,* **MAX YOUNGREN** | *MS Student, Plant Protection Science, Cal Poly San Luis Obispo,* **MATTHEW GRIESHOP** | *Director, The Grimm Family Center for Organic Production and Research at Cal Poly San Luis Obispo,* **SHUNPING DING** | *Associate Professor, Dept. of Plant Sciences and Wine and Viticulture, Cal Poly San Luis Obispo*

Lettuce Fusarium Wilt

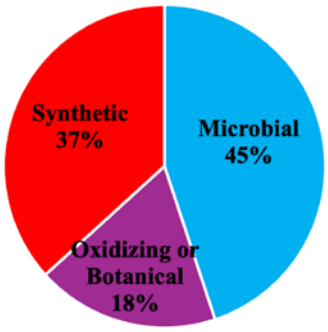
Fusarium wilt has become one of the most challenging diseases for California lettuce growers. Once established, the fungal pathogen that causes this disease, Fusarium oxysporum *f. sp.* lactucae, persists in production soils indefinitely, increasing its abundance by growing on suitable hosts. In the case of this forma specialis, or special form of the fungus, its favored host is lettuce. The fungal spores spread easily between fields, primarily through infested soils on equipment. As a vascular disease that infects through plant roots, it disrupts water and nutrient transport, often leading to unmarketable heads or dead plants (Gordon and Koike 2015). Because the pathogen can persist in soil and be moved during cultivation and field preparation, it often passes unnoticed through rotations with other crops, allowing small hotspots to expand into fieldwide problems once susceptible lettuce is planted again.

Fusarium oxysporum pathogens are notorious for developing genetic variations that allow them to overcome cultivar resistance (Edel-Hermann and Lecomte 2019). In California, there has been growing evidence of new variants, causing concern that management is becoming increasingly challenging (Nayak et al. 2025). At the same time, fumigation and other conventional chemical options are either restricted, ineffective or economically impractical. A rapidly expanding market of soil-applied biological products marketed for Fusarium wilt suppression, soil health, and improved crop resilience has stepped into this gap.

The Promise of Biological Products in Disease Management

Fusarium wilt has become an attractive target for an industry of soil-applied biological products often referred to as "biologicals." Some of these products are formulations of one or more microbial species that have the potential to colonize plant roots, protecting them from pathogens while providing numerous other benefits such as improved nutrient acquisition and abiotic stress tolerance. While many of these microbes and their potentially beneficial roles in soil or plant health have been well documented in scientific literature, the question lies in whether their isolation, commercial formulation and augmentation into production agricultural soils can lead to the same benefits across a variety of crops, advancing sustainably and providing a return on investment for growers.

In response to grower demand for research on the efficacy of these products, we wanted to test those claims under increasingly realistic production conditions to determine whether commercial soil-applied biologicals provide Fusarium wilt suppression on iceberg lettuce when scaled from greenhouse trials to small-plot experiments and ultimately to commercial lettuce fields. Most products evaluated in our study were based on commercial formulations of biologicals, predominantly bacteria, fungi or microbial consortia, and were marketed either as registered biofungicides, claiming a pest suppressive effect, or biostimulants, only claiming plant health improvements. In addition, we tested an oxidizing product and a botanical product, both of which are National Organic Program-compliant and work by directly suppressing the pests. In practice, growers apply these products with the expectation that they will either directly suppress Fusarium wilt or indirectly reduce losses by improving root health or overall plant vigor. Whether those expectations are realistic under commercial conditions remains an open and important question.



Categories of products registered for lettuce Fusarium wilt management in California from CDMS (https://www.cdms.net/). Total products = 50.

What We Found

Initial greenhouse disease suppression trials were conducted under artificially introduced inoculum pressure to determine whether nine different products, including microbial biofungicides consisting of single-species bacteria, multi-species bacterial blends and a fungal-based Trichoderma product, could reduce Fusarium wilt development under controlled conditions. These greenhouse trials also evaluated a botanical cinnamon oil and an oxidizing agent composed of hydrogen peroxide and peroxyacetic acid.



Three trial types conducted. Greenhouse and small-plot trials took place at Cal Poly San Luis Obispo campus, San Luis Obispo, CA, and production field trial took place in Santa Maria, CA. (Photos by Evan Tamayo)

In these trials, the disease developed rapidly on the susceptible iceberg lettuce cultivar, and no biological or low-risk product consistently reduced disease severity relative to untreated diseased controls. The subsequent small-plot field trials narrowed the focus strictly to biological-based programs, utilizing single- and multi-species bacterial and fungal products, as well as a mixed formulation containing both. To establish a performance benchmark across both research settings, the synthetic FRAC 12 fungicide, fludioxonil, was included as a positive control. Ultimately, results from the small-plot trials were similar; disease incidence and mortality increased over time across all treatments, and no product, including fludioxonil, provided substantial suppression of Fusarium wilt.

Cost Considerations

In consulting with growers on product selection for the production field trials, cost emerged as one of the ➲

Helping Farmers Grow NATURALLY Since 1974
COMPOST
COMPOSTED DAIRY MANURE 1.25-1.50-2.5 QUALITY GUARANTEED
FEATURING:
Stable and nutrient rich source of organic matter
Pathogen Free
Weed Free
Rich in Micro-organisms
HELPING FARMERS GROW NATURALLY SINCE 1974
NEW ERA FARM SERVICE
Office: 559-686-3833 Fax: 559-686-1453
2904 E. Oakdale Ave. | Tulare, CA 93274
newerafarmservice.com

most important considerations when selecting products to test, particularly given the narrow margins under which lettuce is often produced. We collected estimates from local distributors or manufacturer representatives and found that the products we were considering varied widely in cost per acre, depending on product type and rates required to complete a labeled or recommended program on lettuce. Products containing the fungus Trichoderma sp. as the primary active ingredient stood out as more expensive compared to the bacterial-based products, with programs ranging from $145 to $450 per acre, whereas bacterial-based programs tended to fall around $50 per acre. With such a wide selection of products on the market, additional considerations for concentration of active ingredients, many of which are based on similar microbial species, viability, and ease of application based on formulation should be made.

Where it Matters Most: Production Scale Field Trials

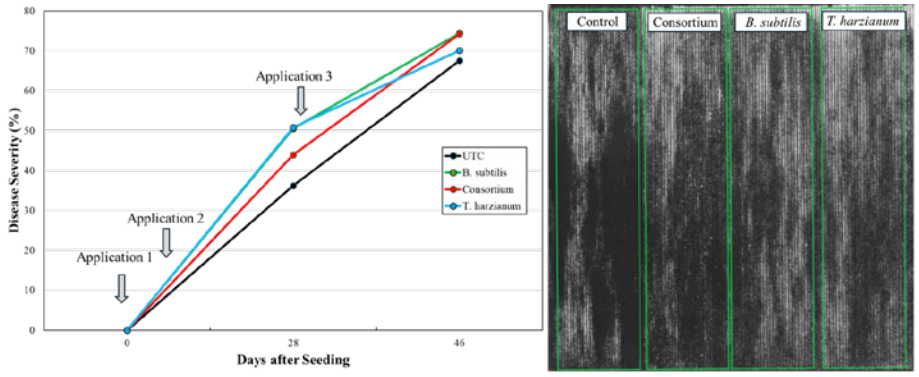
Commercial-scale trials conducted in Santa Maria, CA, provided the most representative assessment of product performance. Four treatments included: 1. Untreated control, 2. *Bacillus subtilis* QST 713, 3. a biostimulant blend of *Rhodopseudomonas palustrus and Bacillus* spp., and 4. *Trichoderma harzianum* T-78. They were applied through the drip irrigation water on roughly three-acre strips per treatment across three fields that had a known history of lettuce Fusarium wilt. Application timing included an initial application at seeding, a second application one week later, and a final application three weeks after seeding. This protocol was replicated across three iceberg lettuce field blocks within the same ranch, and each block was approximately 12 acres. Although all three field blocks were known to be infested, disease severity was only high enough for measurement in one field due to the use of a susceptible cultivar in that field.

Within that field, no soil-applied biological consistently reduced Fusarium wilt losses relative to untreated areas, which ultimately led to the early termination of the crop due to extensive mortality. The overall pattern was clear: the efficacy often suggested in promotional materials was not reflected in our findings at any scale. From controlled greenhouse trials through commercial-scale production, no soil-applied treatment provided reliable Fusarium wilt suppression.

What These Results Mean for Growers

Across greenhouse trials, replicated small-plot field trials, and commercial lettuce field trials, soil-applied biological products did not provide control of lettuce Fusarium wilt. This does not suggest that biologicals lack value in specialty crop production, as many growers have observed benefits in specific crops. However, these results align with those of other academic researchers who have tested similar products for lettuce Fusarium wilt management in California, indicating that current products are unlikely to function as stand-alone solutions for management of lettuce Fusarium wilt, particularly under high disease pressure (Wang 2025, LeBlanc 2024). Integrated management approaches that emphasize cultivar selection, planting timing, crop rotation, sanitation, and sound agronomic practices remain the most reliable tools for reducing disease risk. Biological products may contribute to incremental benefits under specific conditions, but their use should be informed by independent field data and realistic expectations regarding disease suppression and return on investment.

More broadly, these findings emphasize the importance of context when evaluating biological products and integrating them into disease management programs. Unlike traditional agricultural inputs, biological products are living systems, and their performance can be strongly influenced by how they are handled prior to application, how and when they are applied, and the soil and environmental conditions into which they are introduced. Factors such as soil type, moisture, temperature, cropping history, and existing microbial communities can all affect whether a product establishes, persists or provides any measurable benefit. As regulatory and market pressures continue to encourage adoption of lower-risk inputs, there is a growing need for research that defines where, when, and how biological products are most likely to provide value. Continued investment in field-scale research, improved diagnostics, and clearer performance benchmarks will be essential for advancing Fusarium wilt



Disease progression in a commercial field trial with natural infestation of lettuce Fusarium wilt. Left panel: disease progression expressed as a weighted severity index calculated by scoring plants on a 0 (healthy) to 4 (dead) scale within systematic grid-based assessment squares. Each square covered two 80-inch beds and contained approximately 100 plants, with the index representing the proportion of plants at each score relative to the total plants per square. Assessment was conducted on 28- and 46-day post-seeding. Right panel: normalized difference vegetation index (NDVI) heatmap of the same field 48 days after seeding (photo courtesy: Kaitlin Rim, aerialPLOT). Brighter areas indicate higher plant vegetation.

management. With better alignment between product claims, agronomic context, and independent data, biologicals can be more effectively positioned as components of integrated disease management systems.

Acknowledgements

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number ***G223-25-WA509*** *through the Western Sustainable Agriculture Research and Education program under project number* ***GW25-008****. USDA is an equal opportunity employer and service provider. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.*

Evan Tamayo is also a recipient of the 2024–2025 CSU ARI-NEXTGEN Student Fellowship. We thank ARI for partial funding of this work.

Additional support:
Grimm Family Center for Organic Production and Research

Aerial Imagery conducted by aerialPLOT: Kaitlin Rim

Research Assistants: Jenna Keller, Skye Reading, Arlo Grieshop, and Samantha Buie

Farm Management: Jim Green, Brandon Sanders, and Ernie Ford

Christophor Height for consulting on the project

References

Edel-Hermann, V., and Lecomte, C. 2019. Current Status of *Fusarium oxysporum Formae Speciales* and Races. Phytopathology® 109:512–530. https://doi.org/10.1094/PHYTO-08-18-0320-RVW.

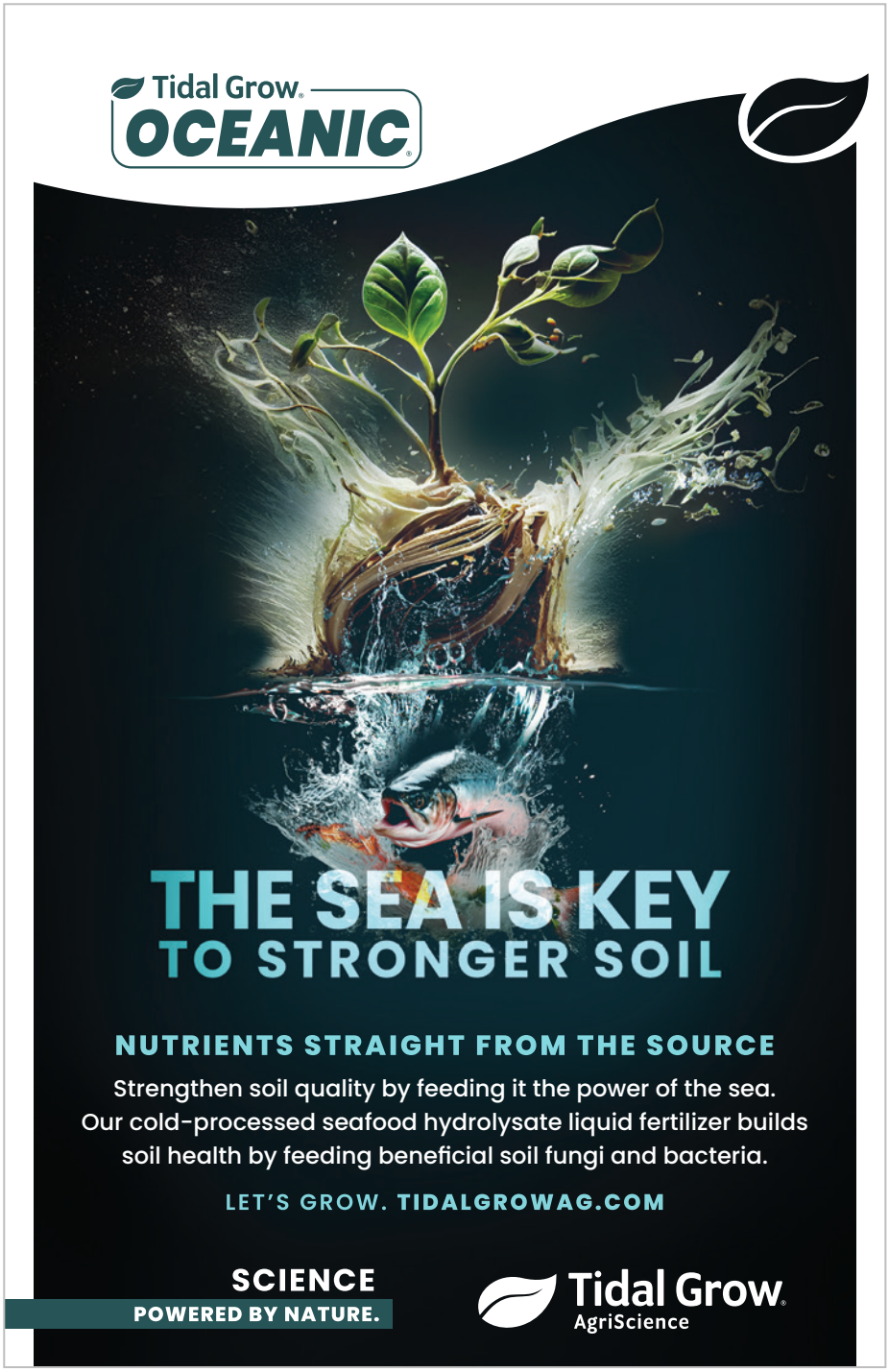
Gordon, T. R., and Koike, S. T. 2015. Management of Fusarium wilt of lettuce. Crop Protection 73:45–49. https://doi.org/10.1016/j.cropro.2015.01.011.

Nayak, S., Richardson, K. L., Putman, A. I., LeBlanc, N. R., Martin, F. N., Li, N., and McCreight, J. D. 2025. Detection of novel pathogenic variants of Fusarium oxysporum f. sp. lactucae in California. Plant Pathology 74:295–307. https://doi.org/10.1111/ppa.14019.

LeBlanc, N. 2024. Application of soil amendments for improved soil health and management of fusarium wilt of lettuce. https://calgreens.org/wp-content/uploads/2024/12/CLGRP_2024_FinalReport_LeBlanc.pdf

Wang, Y. 2025. Field evaluation of fungicide for controlling lettuce Fusarium wilt https://ucanr.edu/sites/default/files/2025-02/407525.pdf

Comments about this article? We want to hear from you. Feel free to email us at article@jcsmarketinginc.com



CDPR Proposing to Greatly Expand Its Air Monitoring Network for Pesticides

By **ROGER A. ISOM** | *President/CEO Western Tree Nut Association*

The California Department of Pesticide Regulation (DPR) has announced plans to expand its statewide Air Monitoring Network (AMN). DPR released a proposal detailing plans to expand from five to 10 long-term air monitoring stations and add a new mobile platform to better assess pesticide concentrations in agricultural communities. The department is holding a 60-day public comment period to seek input on proposed locations for new air monitoring stations and will host a virtual public workshop on April 14 to discuss the proposal. DPR's Air Monitoring Program was initiated in 2011 and currently collects and analyzes data in Merced, Ventura, Santa Barbara, Kern and Monterey counties. More specifically, the five existing sites are in Delhi (Merced County), Oxnard (Ventura County), Santa Maria (Santa Barbara County), Shafter (Kern County) and Watsonville (unincorporated Monterey County).

Expansion Plans and New Monitoring Sites

The 2024-25 state budget provides permanent funding to DPR to expand ambient air monitoring to a total of 10 stations. DPR used an updated, data-driven prioritization process to identify five counties, Tulare, Stanislaus, Imperial, Siskiyou and San Joaquin, as leading candidates for four new AMN stations. To reach a total of 10 full air monitoring sites, DPR's expansion plan builds on five existing AMN stations to include:

- Conversion of an existing site providing limited pesticide sampling to a full monitoring station in Fresno County
- Up to four (4) new AMN stations in prioritized counties
- New mobile monitoring station to add capacity for additional studies

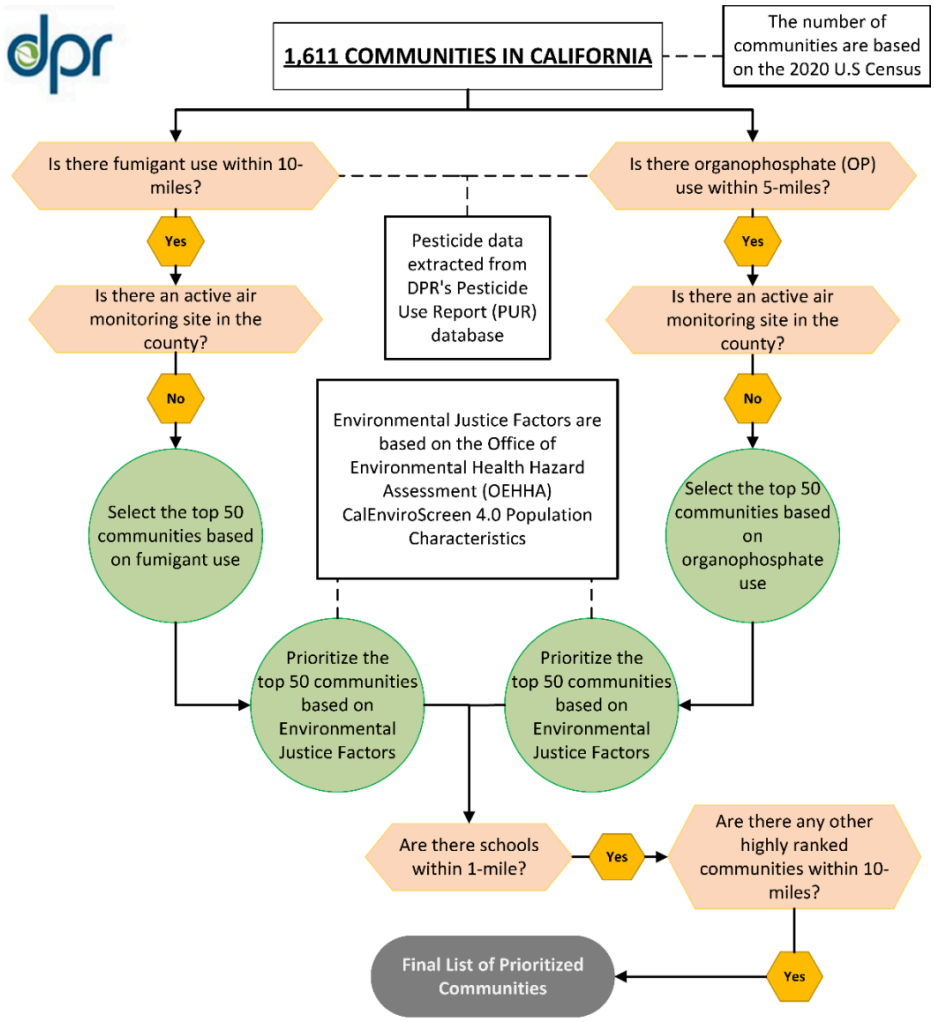
The Fresno County site is in Parlier, which was established in 2016 for the monitoring of 1,3-D alone. This station is DPR's only long-term monitoring location that is not located at a school site. Relocation of the Parlier station to a school and expanding monitoring to all 40 chemicals would integrate Fresno County into the AMN.

How Sites Are Selected

For the other four sites, CDPR will follow a site selection procedure to evaluate communities across the state. This process is updated with new data every 3 to 6 years and informs decisions on potential stations to be added to the monitoring network. Through this process, communities in the state are ranked from highest to lowest based on their proximity to fumigant and organophosphate applications. Fumigants are prioritized because they are used in large amounts and readily enter the gas phase, while organophosphate pesticides are both widely used and share a common biological mechanism which can produce an additive effect in terms of their toxicity, presenting a greater potential health hazard than non-fumigant, non-organophosphate pesticides.

While not part of the formal prioritization procedure, historical use of non-fumigant, non-organophosphate pesticides may be considered when deciding between otherwise similar monitoring locations. Because the site prioritization process develops independent rankings of the top 50 communities based on either organophosphate or soil fumigant usage, the outcome of the site prioritization process is a list of up to 100 communities. In practice, some communities may appear on both lists, lowering the total below 100, while selection for communities containing

'The outcome of this process is a 'short list' of communities where stations may be ideally situated to collect data regarding potential pesticide exposure.'



Flow chart of prioritization procedure. The chart identifies the decision pathway for communities to be included in the final list of prioritized communities; communities not meeting one or more criteria are not included on the final list (Source: California Department of Pesticide Regulation.)

schools and regions containing more than a single high-ranking site further reduces the total. Therefore, the outcome of this process is a "short list" of communities where stations may be ideally situated to collect data regarding potential pesticide exposure.

Monitoring Requirements and Next Steps

Once a community is selected for monitoring, an appropriate location must be found within a selected community that satisfies certain requirements to ensure that results are representative of the ambient air. DPR evaluates prospective monitoring locations and periodically reevaluates existing monitoring locations to ensure they comply with U.S. EPA's ambient air siting criteria. Monitoring sites must meet the following minimum criteria:

- 2 to 15 meters above the ground
- At least 1 meter horizontal and vertical distance from supporting structures
- At least 20 meters from trees
- Distance from obstacles should be at least twice the obstacle height
- Unobstructed air flow for at least 270 degrees
- Sites must also satisfy certain access requirements including:

o Accessibility of the site to sampling personnel at the time of sampling

o Availability of electricity

o Protection of equipment from loss or tampering

According to CDPR, DPR scientists evaluate prospective sites to make sure they meet the above requirements prior to equipment installation. If no acceptable sites can be found within a selected community, or if DPR cannot identify cooperators

'This process produces a 'short list' of communities best suited for monitoring potential pesticide exposure.'



to host the site, then an alternative community must be considered.

After the initial evaluation, CDPR generated a list of 71 unique communities distributed across 14 counties. After further analysis reviewing existing sites and distances from these sites, the list has been reduced to 29 communities across five counties including Stanislaus, San Joaquin, Imperial, Siskiyou and Tulare. CDPR then ranked the counties based on the number of high-ranking communities within each county and came up with the following ranking:

COUNTY	# OF TOP 50 COMMUNITIES	PRIORITY BY CDPR
Tulare	27	1
Stanislaus	13	2
Imperial	6	3
Siskiyou	6	4
San Joaquin	2	5

CDPR is considering comments through May 11 and is asking for feedback on the ranking of the counties and which of the communities within each county should be the target sites for the air monitoring network. It might also be important to weigh in on how the mobile monitoring station will be utilized and how CDPR will ensure it also meets the EPA siting criteria.

Comments about this article? We want to hear from you. Feel free to email us at article@jcsmarketinginc.com

CATION-EX5 PLUS

START REMOVING SODIUM
FROM YOUR SOIL IMMEDIATELY



INSTANT SOLUTION TO IMPROVE
WATER MOVEMENT AND AVAILABILITY

AgroPlantae

www.agroplantae.com



ALL THE FERTILIZER KNOWLEDGE YOU COULD WANT.

AND SOME YOU PROBABLY DON'T.

Ask us anything about fertilizer and we'll likely talk your ear off. That's the kind of enthusiasm that goes into every drop of our PrG™. This formula combines nitrogen, potassium and iron that work synergistically with phosphorus to increase efficiency and nutrient uptake. We think that's really cool – and your almonds will too.

Find your weirdly knowledgeable agronomist at AgroLiquid.com

PrG™

POWERED BY Nutriq™

PrG™ and Nutriq™ are trademarks of AgroLiquid. ©2025 AgroLiquid. All Rights Reserved.