

CALIFORNIA AGRICULTURAL RESEARCH & INNOVATION ROADMAP

Supporting Next-Generation Tools for California Agriculture



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RESEARCH INSTITUTE**



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California
Community
Colleges



CALIFORNIA DEPARTMENT OF
FOOD & AGRICULTURE

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources



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FARMERS, RANCHERS, PARTNERS & FRIENDS:



Agriculture is deeply woven into the fabric of California's economy, culture and identity. What's more, California's farmers and ranchers produce a bounty of fruits, nuts, vegetables and animal products that play a critical role in feeding our neighbors in the Golden State, across the country and all over the world. But today's producers are facing obstacles including water scarcity; climate change; increasing pest and disease pressures; workforce skills gaps and labor availability; a complex regulatory environment; and increasing production costs. The California Agricultural Research & Innovation Roadmap is a critical part of the solution to these challenges and others, and a pathway to opportunity not only for agriculture, but for all Californians.

Importantly, the plan — which is an extension of AgVision adopted in 2023 — is rooted in collaboration, as no one entity can accomplish what is needed on their own. This plan leverages one of our state's greatest assets: a world-class higher education system with a long history of driving agricultural progress. By aligning the expertise of the University of California, the California State University system, and our community colleges around shared research priorities, we are creating a unified approach for delivering research that is responsive to industry needs, rooted in science, and focused on practical, real-world solutions. The research priorities will span the duration of the plan (2026-2036), while more short-term innovation priorities designed to inspire private investment, entrepreneurs, technology partners and others will be refreshed every two years through the California AgTech Alliance, a partner in the collective roadmap.

To realize the full promise of this work, we also need strong partnership from industry. Innovation only reaches its potential when ideas move beyond the lab and into the field, becoming solutions that producers can adopt and trust. By supporting the entire innovation and commercialization pipeline — from concept to adoption — we create an ecosystem where good ideas can become practical tools that strengthen productivity, efficiency and resilience across California agriculture.

Innovation and ingenuity are part of who we are as a state, and this plan is a reflection of those values. I look forward to ongoing efforts in support of this roadmap, as California agriculture continues to make the state a better place to live because of what we grow and how we grow it.

Karen Ross
Secretary
California Department of Food and Agriculture

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THINKING NEAR AND LONG TERM

California Agricultural Research & Innovation Roadmap embraces both a long-term focus via the research priorities identified in collaboration with all partners included in this plan, and near-term solutions through innovation priorities, spearheaded by the California AgTech Alliance.



BACKGROUND: A FOUNDATION FOR THE FUTURE OF CALIFORNIA AGRICULTURE

California agriculture holds a legacy of innovation, productivity and global leadership. At the same time, the farmers and ranchers who grow and produce food here are facing mounting pressures, from water scarcity and climate volatility to complex regulations, labor shortages and global market disruptions. These challenges are real and growing, but so is our capacity to address them through research, technology and innovation that are commercialized and put to use. In doing so, we can also create opportunity and allow California agriculture to thrive well into the future.

This Agricultural Research & Innovation Roadmap is not just about science — it's about securing California's agricultural future. It's about making sure the food grown here continues to nourish communities, support jobs and steward the land. It's about recognizing that agriculture is not separate from the health and wellbeing of California, but rather foundational to it.

At over \$61 billion in agricultural production and more than \$100 billion in related economic activity, agriculture is a cornerstone of California's economy. But more than that, it shapes the landscapes we live in and the local communities we care about. A resilient agricultural sector is essential not just for farmers and ranchers, but for every Californian who benefits from what we grow and how we grow it, along with consumers around the globe who rely on the bounty produced in the Golden State.



A COLLABORATIVE APPROACH

No single institution can carry the future of agricultural research and innovation alone. That's why this plan was developed through a collaborative approach that brought together farmers and ranchers and groups that represent them, along with public, private and academic leaders to develop the plan.

This plan also recognizes that complex challenges require multidisciplinary and multi-institutional teams. Whether the issue is climate adaptation, water optimization, food safety or economic viability, progress happens when biologists work alongside engineers, economists, data scientists, entrepreneurs, farmworkers and farmers.

Institutional partners in this effort include:

- The California Department of Food and Agriculture (CDFA), which provides essential leadership at the state level to convene stakeholders — farmers, ranchers, researchers, industry groups, policymakers and community voices — to tackle challenges facing California agriculture while advancing the public good.
- University of California Agriculture and Natural Resources (UC ANR), which brings decades of trusted research and extension work connecting campuses to communities and translating science into solutions on the ground.
- The Agricultural Research Institute (ARI), housed within the California State University (CSU) system, which offers applied research solutions to address real-world challenges, while also helping develop California's future agricultural workforce.
- California Community Colleges, which play a vital role in preparing the next generation of agriculture professionals by offering accessible career pathways.
- Western Growers, which advances agricultural innovation by supporting industry-driven research and the development and adoption of practical, scalable solutions across agricultural technology, food safety, biological crop protection and sustainable production systems, ensuring research addresses real-world farm needs.
- The California AgTech Alliance, funded by the California Department of Business and Economic Development as part of the California Jobs First Initiative, is focused on advancing agricultural innovation and workforce development. The Alliance is guided by an industry advisory board reflective of agriculture in California and tasked with identifying innovation priorities.

These institutional partners have agreed to meet on an annual basis and track and share progress against this plan.

WORKFORCE DEVELOPMENT GOES HAND IN HAND

While research and innovation are at the crux of this plan, they are not the only areas in which focus is needed to secure California's agricultural future. A technologically skilled and adaptable workforce is also essential. Jobs in agriculture are increasingly about innovation, science, technology and entrepreneurship. While not the direct purview of this plan, many of the partners included here also hold important roles in educating and training for ag workforce skills needed today and in the future. As such, this plan will serve as inspiration for training and curriculum programs and supplement other workforce development efforts, including California Jobs First and the Specialty Crop Workforce Development Program. To learn more about these efforts, visit JobsFirst.ca.gov or cdfa.ca.gov/Specialty_Crop_Workforce_Development.

PARTNER COMMITMENTS: A BLUEPRINT FOR ACTION AND IMPACT

This plan is not a theoretical roadmap, but rather an applied research and commercialization agenda that will move beyond words on paper to drive research and innovation around real-world needs and emerging opportunities. Each participating institution has committed to turning this plan into action, with each entity doing its part to move from ideas to implementation and experimentation to adoption and widespread impact. The plan is structured to support this continuum, and collaboration across the public and private sector is vital to its success. Consider this:

Partner	The associated partner will support the plan by:	How success will be measured, e.g., KPIs
CDFA	<ul style="list-style-type: none"> Fostering collaboration opportunities among partners. Convening state agencies to communicate the latest science, innovations and industry progress and to inform the development of public policy. Aligning grant opportunities with the plan and prioritizing funding for projects that support the agreed-upon research and innovation agenda. 	<p>Convening: Establish a routine calendar to bring partners together on priorities.</p> <p>Updates: Updates to the State Board of Food and Agriculture throughout the year.</p> <p>Grant Programs: The priorities of the roadmap will be incorporated in relevant grant program requests for proposals, specifically the Specialty Crop Block Grant Program; Pest Management Programs of the Office of Pesticide Consultation Analysis; relevant Climate Smart Ag programs; and the Fertilizer Research and Education Program.</p>
UC ANR	<ul style="list-style-type: none"> Prioritizing funding for agricultural research initiatives that align with the roadmap. Translating research to policymakers through the UC ANR Policy Institute. Helping farmers translate research into practice through technical assistance and Cooperative Extension programs. Providing the roadmap to new hires to complement their needs assessment work. Coordinating discussions on current and future science, research needs and development of multi-stakeholder grant proposals through Program Teams. 	<p>Alignment:</p> <ul style="list-style-type: none"> Number of multi-disciplinary research collaborations formed specifically to address roadmap priorities. External grant dollars secured for roadmap-aligned research area. <p>Researcher Onboarding:</p> <ul style="list-style-type: none"> Number of newly hired UC ANR academics and specialists formally onboarded with the roadmap. Percentage of new researchers who identify at least one roadmap priority as part of their program plan within their first year. <p>REC Activation:</p> <ul style="list-style-type: none"> Annual number of aligned research projects on site.
ARI	<ul style="list-style-type: none"> Prioritize and allocate ARI Core Funding to research initiatives that directly address the high-priority gaps identified in the roadmap. Establish and fund a distinct “Collaborative Innovation Grant” specifically for multi-institutional and multi-disciplinary teams. These projects must integrate partners from at least two different systems (e.g., CSU & UC ANR and/or Community Colleges) and an industry partner and can demonstrate a clear pathway to improving the economic efficiency, productivity and sustainability of California agriculture. Supporting skills development for students in the areas outlined in the plan. Developing curricula to help build the skills and knowledge necessary for innovation and success. 	<p>Alignment: Percentage of total ARI annual funding awarded to projects that map directly to the key roadmap priorities.</p> <p>Industry Matching Ratio: The dollar amount of industry/private sector co-investment attracted per dollar of ARI strategic funding.</p> <p>Collaboration: The number of cross-system collaborations (e.g., CSU+UC+Industry) and the amount of external matching funds (CDFA, Western Growers, etc.) leveraged per ARI dollar.</p> <p>ROI: Estimation of ROI and/or adoption by industry or growers.</p> <p>Skills Development: The percentage of ARI-supported students who complete industry-validated “Roadmap Skills” training and successfully transition into California’s agricultural workforce.</p> <p>Curricula Development: Number of new or modernized CSU course modules that have been reviewed or “endorsed” by industry partners to ensure they meet contemporary technical standards.</p>

Partner	The associated partner will support the plan by:	How success will be measured, e.g., KPIs
Community Colleges	<ul style="list-style-type: none"> • Co-developing curricula that aren't already mapped in the system. • Aligning workforce initiatives with the roadmap. • Engaging in career and recruitment events to encourage students to enter careers in agriculture. • Supporting apprenticeship pathways for continued growth of the current and new ag workforce. • Providing reskilling and upskilling for individuals working in agriculture. • Engaging in climate initiatives focused on sustainable agriculture. 	<p>Alignment: Align programs in support of the roadmap and students. Specifically:</p> <ul style="list-style-type: none"> • Expand short-term training in equipment mechanics, food safety, and irrigation. • Launch ESL + technical skills programs in high-employment regions. • Develop 25 industry co-designed courses in automation and precision ag. • Establish 500 new work-based learning placements. • Create stackable credential pathways at 15 colleges leveraging the AgTec Demonstration project. • Provide wraparound services for 1,000 students.
Western Growers	<ul style="list-style-type: none"> • Engaging farmers in the review and confirmation of roadmap research and innovation priorities. • Aligning agtech innovation solutions with the roadmap. • Driving industry adoption of research findings and innovation solutions. 	<p>Validation: Number of growers engaged annually to validate and refine roadmap research and innovation priorities.</p> <p>Alignment: Number of agtech solutions, pilots or startup programs explicitly aligned to roadmap priorities.</p> <p>Adoption: Number of growers participating in on-farm trials, pilots or demonstrations of roadmap-aligned technologies.</p> <p>Relevance: Use of roadmap-aligned innovation outcomes to inform policy discussions, regulatory implementation and economic feasibility assessments relevant to growers.</p>
California AgTech Alliance	<ul style="list-style-type: none"> • Using the roadmap to inspire the areas of focus for the Alliance. Every two years, the Alliance will develop a list of farmer and workforce-driven innovation priorities with commercialization potential that will be updated in this document, ensuring the plan includes both long-term innovation and short-term solution commercialization. 	<p>Adoption: Number of Alliance partners using the roadmap for program development.</p> <p>Field Validation and Demonstration: Number of field days, trials and tests focused on innovation priorities.</p> <p>Policy, Investment & Funding Influence: Number of funding proposals, public investments, or private partnerships that reference the roadmap as justification or alignment. Amount of capital (public and private) influenced or directed toward roadmap-aligned priorities.</p>

HOW CAN INDUSTRY SUPPORT THE ROADMAP?

Those in the California agricultural community are valuable partners in the success of this roadmap. We encourage participation of industry in several ways, including by serving as an ongoing source of information about research and innovation needs. In addition, we encourage those who fund agricultural research to do so in alignment with the priorities outlined here. For more information on how you can get involved, contact Josh Eddy, executive director of the California State Board of Food and Agriculture, at 916 654 0462 or josh.eddy@cdfa.ca.gov

LONG TERM: RESEARCH PRIORITIES

The following research priorities are intended to guide academic and other research for the duration of the 10-year plan. Research that aligns with these areas will be prioritized by partners in this effort (Page 5).

Priority A: Climate Resilience and Environmental Sustainability

Why it matters: Climate change is no longer a distant threat — it's affecting agricultural productivity, crop quality and long-term viability of California agriculture, as well as the ecosystems upon which agriculture depends. Extreme heat and drought, shifting precipitation patterns and the effects of those patterns, along with new pests and diseases, mean farmers and livestock producers need tools to adapt. At the same time, there is opportunity to further improve agriculture's environmental impacts and benefits, and support biodiversity and ecosystem health.

Potential research topics:

- Drought, heat and adaptable crops and rootstocks
- Healthy soils, carbon sequestration
- Ecosystem services and tradeoff analysis
- Breeding/variety diversification for climate resilience, yield and shelf life
- Livestock genetics for improved productivity, animal health and welfare, methane reduction, feed efficiency and more
- Agroecology, organic and regenerative production systems
- Urban and controlled-environment agriculture
- Soil health and management
- Rangeland and grazing systems
- Disaster resiliency, preparedness and response
- Aquatic food production systems



LONG TERM: RESEARCH PRIORITIES

Priority B: Water Management, Use Efficiency and Quality

Why it matters: Water scarcity, groundwater regulation and water quality are defining issues for California agriculture. Producers must increase water efficiency, protect water quality, enhance groundwater recharge and navigate tighter regulations. Upper watershed management must also improve to increase water supplies. At the same time, smarter water use can improve resilience and economic prosperity.

Potential research topics:

- Groundwater recharge and Sustainable Groundwater Management Act (SGMA) compliance
- Salt accumulation and water quality from fertilizers
- Precision irrigation technologies and water-use modeling
- Breeding for improved water and fertilizer efficiency
- Upper watershed management
- Utilization of brackish and reclaimed water sources



LONG TERM: RESEARCH PRIORITIES

Priority C: Integrated Pest and Disease Management

Why it matters: Growers are losing access to crop protection tools at a time when pest and disease threats are intensifying, creating a need for effective, scalable, economically viable and environmentally safe alternatives to maintain productivity, reduce input costs and protect public trust.

Potential research topics:

- Biological alternatives to conventional pesticides
- Integrated Pest Management (IPM) solutions
- Vaccines and immune system support for livestock
- Predictive models for pests and diseases under climate stress
- Breeding for pest- and disease-resistant cultivators
- Alternative application methods

Priority D: Food Safety and Consumer Health

Why it matters: Food safety concerns are increasing with climate change, evolving production practices and SGMA implementation. Research is needed to understand contamination pathways and help growers implement safe, science-based practices with consideration for a One Health approach connecting plant, environmental and human health.

Potential research topics:

- Pathogen movement from soil, water and animals
- On-farm mitigation strategies for food safety concerns
- Risk assessment for food safety vulnerabilities
- Postharvest, commodity-specific best practices
- Human-wildlife interactions
- Early detection of in-field contaminants



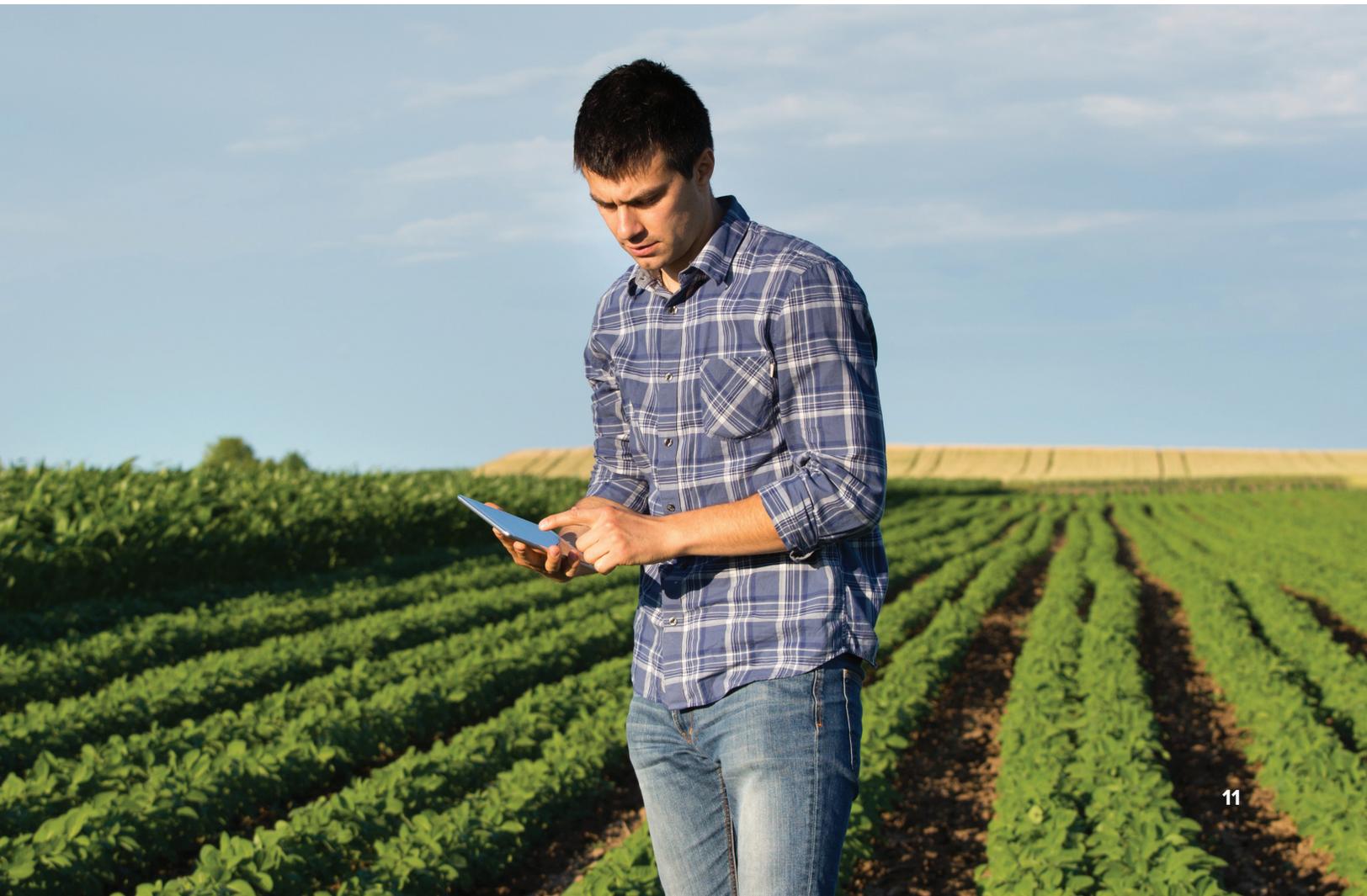
LONG TERM: RESEARCH PRIORITIES

Priority E: Technology, Automation and Data-Driven Farming

Why it matters: Labor costs, shortages, extreme heat, worker safety and compliance requirements are driving the need for automation and smarter farm management. Advanced tools can boost efficiency and enable compliance with evolving food safety and traceability mandates, but require the upskilling of the existing workforce and attracting a new generation of workers for the jobs of tomorrow.

Potential research topics:

- Autonomous vehicles, robotic harvesting and mechanized weeding
- Utilization and management of drones/UAVs
- Precision agriculture equipment for input efficiency
- Digital tools for traceability, compliance and decision-making
- Artificial intelligence, yield mapping and remote sensing
- Informatics and big data
- Workforce development and upskilling farmworkers
- Carbon-based energy alternatives



LONG TERM: RESEARCH PRIORITIES

Priority F: Economics, Policy and Adoption Pathways

Why it matters: Even the best research won't be adopted without a clear economic case or policy support. Farmers and ranchers need data that shows sustainability practices will pencil out, and policymakers need science-backed insights to design effective and realistic regulations. At the same time, as markets evolve and supply chains face increasing pressure, understanding logistical, processing and marketing challenges becomes critical to supporting the long-term competitiveness of California agriculture.

Potential research topics:

- ROI and cost-benefit analysis of sustainable practices
- Research to inform smart regulation and policy reform
- Land use economics and competition (e.g., solar vs. ag)
- Supply chain resiliency, logistics and market access (domestic and international)
- Processing, transportation, cold chain infrastructure and labor dependencies
- Circular bioeconomy and manufacturing of high-value products from ag biomass
- Conversion technology that turns waste streams into new products
- Cost-of-production studies
- Regional industry clusters and business support
- Economic value of working landscapes



SHORTER TERM: INNOVATION PRIORITIES

Every two years, through the California AgTech Alliance, industry experts will redefine California's priority innovation areas to ensure they reflect the most urgent and persistent challenges facing agriculture today. These priorities are informed directly by farmers, farmworkers and industry leaders, and are intended to guide innovators toward practical, adoptable solutions that can be deployed in the near term while complementing longer-term research efforts laid out in this roadmap (Page 8). Each priority below outlines the problem context farmers are operating within and the innovation directions needed to address those realities.

Priority 1: Water and Soil Management

Why it matters: California farmers are managing increasing water scarcity, rising input costs and growing regulatory pressure — often simultaneously. They need tools that help them make real-time, field-level decisions about water and soil management while maintaining yields and long-term land productivity.

Potential Solutions:

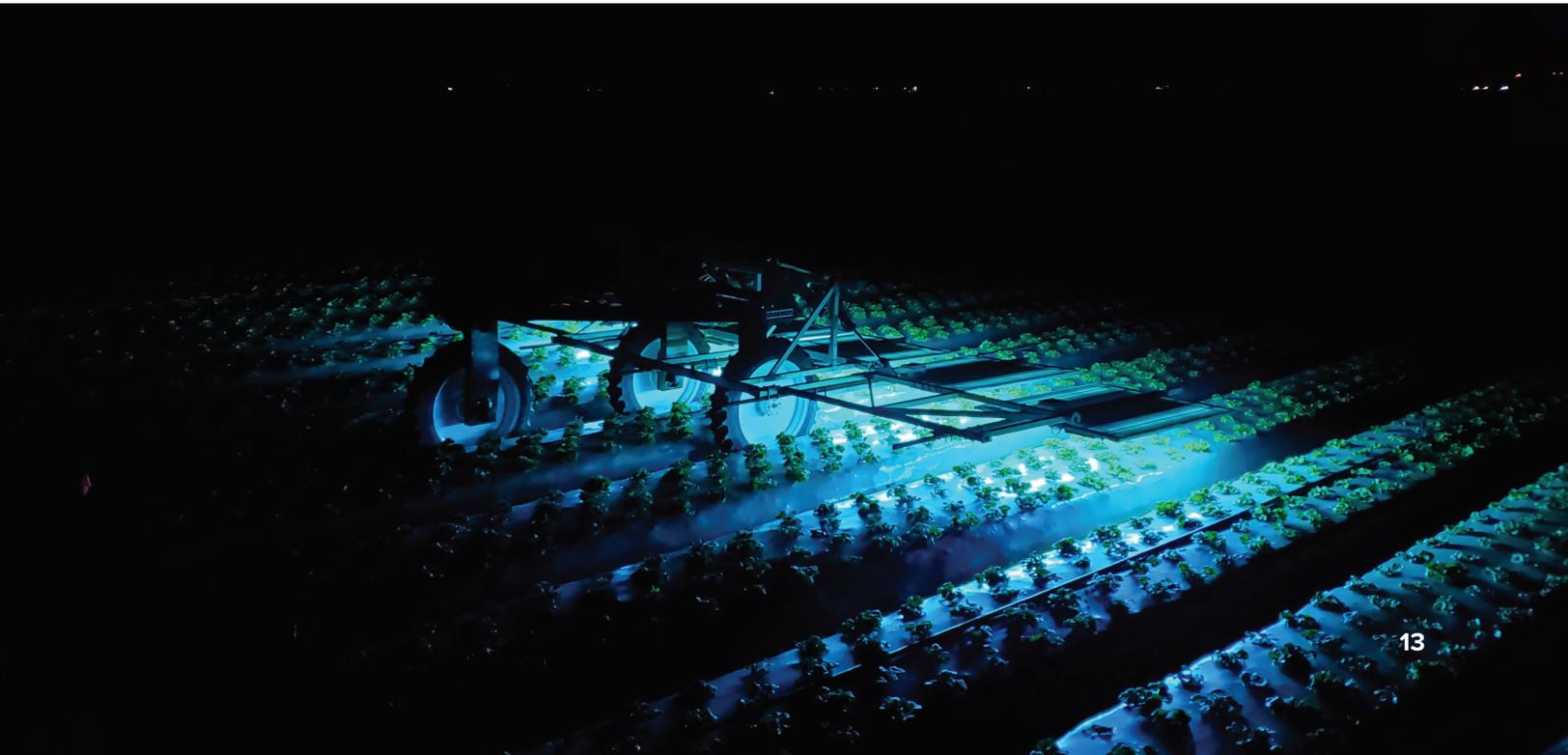
Innovators should focus on scalable technologies and systems that improve water-use efficiency and soil health under variable and constrained conditions. This includes sensing, monitoring and decision-support tools that provide actionable insights on soil biology, moisture and nutrient dynamics, and enable more precise and efficient use of biological and chemical inputs. Solutions must integrate into existing farming operations, reduce risk and demonstrate clear economic and regulatory value to farmers.

Priority 2: Automation and Technology

Why it matters: Farmers are facing persistent labor shortages, rising labor costs, extreme weather and worker safety concerns while still needing to maintain productivity and quality. Automation is no longer optional and must be reliable, affordable and compatible with existing workforce models.

Potential Solutions:

Innovators should develop and advance automation and robotic solutions that enhance operational efficiency and worker safety while supporting, not displacing, the agricultural workforce. Priority is given to technologies that can be adopted incrementally, function in real field conditions and integrate with farm labor and management systems. Successful solutions will demonstrate clear productivity gains, workforce compatibility and pathways to adoption at scale.



SHORTER TERM: INNOVATION PRIORITIES

Priority 3: Pest Management

Why it matters: Farmers are navigating evolving pest pressures alongside tightening regulations, limited chemical options and increased scrutiny from markets. They need pest management solutions that are effective, compliant, economically viable and less reactive.

Potential Solutions:

Innovators should focus on tools and systems that enable precision pest management — improving detection, timing and targeting of interventions. This includes pest monitoring and detection technologies, novel biological solutions and integrated systems that reduce reliance on broad-spectrum chemicals while maintaining crop health and yield. Solutions should be designed to support regulatory compliance and practical on-farm use across diverse cropping systems.

Priority 4: Biomass Management

Why it matters: Farmers are burdened with increasing volumes of agricultural residues and limited, costly disposal options due to air quality regulations and infrastructure constraints. Biomass is often treated as a liability rather than an asset, and disposal slows production and shrinks margins.

Potential Solutions:

Innovators should develop technologies, markets and supporting infrastructure that convert agricultural residues into valuable products or energy streams. Priority will be given to solutions that are economically feasible for farmers, scalable across regions and aligned with California's climate, air quality and sustainability goals. Successful innovations will reduce disposal costs, create new revenue opportunities and integrate into existing agricultural systems and growing incentive programs.



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