RESEARCH ARTICLE

Setting research and extension priorities for agronomic crops in California

Survey shows farmers need more information on new products and technologies, soil health management, and water conservation and storage.

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Abstract

Agronomic crops, including grains, forages, and fiber, are central to California agriculture, yet face many challenges. To ensure resilience, a statewide survey was conducted by the University of California Cooperative Extension service (UCCE) to identify high-priority needs and inform extension programming based on grower, consultant, and allied industry input. The goal was to compare the importance of different topics with the level of satisfaction regarding UCCE's delivery of information on these topics. Survey respondents identified integrated pest management, nutrient and irrigation management, and variety testing as high-priority needs, with overall high satisfaction regarding UCCE's program delivery on these topics. Topics needing more focus (high priority but below-average level of satisfaction) included testing new products, soil health management, and water conservation and storage. Areas of low priority and low satisfaction included niche marketing, emerging crops, organic production, harvest/post-harvest technology, salinity management, compost and manure management, and greenhouse gas emission reductions. To address stakeholder challenges, results from this study suggest that research and extension efforts should prioritize issues directly impacting on-farm crop production. At the same time, areas of low interest reflect a need for more support to engage farmers on these topics, particularly those concerning state environmental regulations and challenges to local and global food production and security.

Agronomic crops — mainly rice, corn, small grains, alfalfa and other forages, oil seeds, dry beans, and cotton — are central to California farming systems. They are currently grown on 3.4 million of the approximately 9 million acres of irrigated land in California, providing food, feed, and fiber for the world. Agronomic crops produce a farmgate value of approximately US$3.2 billion annually in California and are the key feed ingredients supporting the $14.0 billion dairy and beef livestock sectors (CDFA 2023).

Agronomic crops provide management flexibility with adaptability to different soil and climate conditions, such as salinity and droughts, providing resilience for cropping systems and food production throughout California. Agronomic crops also help address pest, disease, and weed management challenges through crop rotations, with some crops like alfalfa supporting biological nitrogen fixation, reducing the need for fertilizer, and contributing to healthy soils (Katerji et al. 2000; Liebman and Dyek 1993; Long et al. 2014; Orloff et al. 2015; Rusch et al. 2013). Despite these benefits, permanent tree crops such as almonds, walnuts, and pistachios are replacing agronomic crops

Rice fields in the Sacramento Valley. In 2020, UC Cooperative Extension conducted a needs assessment to understand key issues facing growers, consultants, and allied industry working in different agronomic crops across the state. *Photo*: tfoxfoto, iStock.

in California, largely due to economic factors such as increasing input costs, as well as market forces such as low commodity prices, higher land values, and higher returns from fruit and nut crops.

To ensure that research and extension efforts supporting agronomic crop production remain strong, University of California Cooperative Extension (UCCE) conducted an agronomy needs assessment in 2020 to understand key issues facing growers, consultants, and allied industry working in different crops and regions across the state. Stakeholder responses for several questions were previously summarized to evaluate top management challenges and factors influencing decision-making, as reported in another paper (Kanter et al. 2021). However, a more specific question that remains for improving agricultural extension programs is to understand which topics are highest priority for stakeholders and how well UCCE is meeting current needs for these topics. Such information is critical to prioritize research and extension activities in response to recent challenges, as well as guide institutional and policy decisions about how to direct resources and funding.

The objective of the current study was to compare how stakeholders prioritize different topics for agronomic crop production relative to the level of satisfaction with UCCE's delivery of information on these topics. We used the quantitative Importance-Performance Analysis (IPA) framework (Martilla and James 1977; Warner et al. 2016). This tool is increasingly used in extension to help identify clientele needs and to prioritize program activities that should receive more time and resources (Galt et al. 2019; Pitas et al. 2020). Participants are asked to rate the importance of different issues and their satisfaction with each issue, revealing whether there are aspects of a program that have perceived importance but low satisfaction (Pitas et al. 2020; Warner et al. 2016). Surveys are often used to determine stakeholder preferences and gaps in information delivery that can be addressed in future extension programming (Garst and McCawley 2015).

UCCE is a statewide program of the UC Division of Agriculture and Natural Resources (UC ANR). This survey is timely because state funding for UC ANR has declined by almost 50% over the past 20 years, adjusted for inflation (Humiston 2021). Moreover, UCCE academic positions have declined from 427 to 269 (37%) over the same timeframe, mainly due to retirements and resignations, creating vacancies in critically needed positions (Humiston 2021). As such, UCCE academic positions are stretched thin, covering multiple counties to serve growing numbers of Californians. At the same time, academics devote more time to securing outside funds for program development and implementation, as reflected by a 63% increase in self-generated funds over the past five years (UC ANR 2019).

Setting research and extension priorities based on input from a range of stakeholders can help demonstrate program value, increasing the relevance and impact of outreach efforts (McClure et al. 2012). Findings from this survey are applicable to extension programs at land-grant universities, as well as to local government and state and federal agencies working in agricultural production and natural resource conservation in California. Results are interpreted with the goal of broadly informing policymakers and research and extension programming, while guiding cost-effective investments to support the viability, sustainability, and resilience of agronomic cropping systems in California.

Collaboration and participation

A central goal of this research was to identify stakeholder needs through a collaborative and participatory approach. As described below, this included developing and disseminating an online survey with a team of UCCE experts and collaborators, piloting the survey with growers and other stakeholders, and partnering with external organizations to increase participation among growers, consultants, and allied industry supporting agronomic crop production. These steps helped capture the diversity of both the crops grown and the agricultural production regions in California, as well as views and opinions from clientele that UCCE is already serving and those not currently engaged with UCCE efforts.

The online survey was conducted in 2020 using Qualtrics software (Qualtrics, Provo, Utah), as described in Kanter et al. (2021). This previous paper contains the full methods and list of survey questions, but key steps are described here. To make this a collaborative process within extension, the Agronomic Crops Program Team, including UCCE advisors, specialists, and other academics, worked with UCCE evaluation specialists from start to finish, helping conceptualize the study, design the survey, and interpret and utilize the results. Evaluation specialists gave a presentation at an Agronomy Program Team meeting regarding the benefits of conducting statewide and collaborative needs assessments, using a previous study on dairy programs as an example (Martins et al. 2019). After that, survey questions were designed with input from the entire research team. A collective decision was made on the sampling frame and the survey distribution channels; as a result, both current UCCE clients and those that are not being served currently were included in the sample. Various stakeholder groups were involved during the survey validation and pilot testing phases. Such a participatory and culturally responsive approach is expected to ensure that the results are usable for all the stakeholders involved (Cousins and Whitmore 1998; Patton 1997).

The survey included 21 questions covering management challenges, industry concerns, reasons for growing agronomic crops, priorities in management decisions, and methods of communication. Following IPA methodology, survey respondents were also asked to rate what they believe should be research and

extension priorities for UCCE and their current level of satisfaction with UCCE's delivery of information on these topics.

To distribute the survey, we used a two-pronged approach. First, the survey was distributed to growers, consultants, and allied industry using UCCE crop and regional contact lists. Lists were compiled and duplicates were removed for a total direct distribution of 4,813. To expand the survey audience and potentially reach those whom UCCE is not already serving, partner organizations distributed the survey using an anonymous link. These partner organizations included commodity boards, crop associations, farm bureaus, county agricultural commissioner offices, water quality coalitions, and input distributors. The survey software kept track of responses that came from the compiled UCCE contacts list and those that came from the anonymous link. A survey response rate could be determined for the compiled list but not for the anonymous link distributed by partner organizations. Email notifications about the survey were sent in July 2020, and the survey was open from July 23 through September 1, 2020.

The survey garnered a total of 483 responses: 320 responses from the compiled contacts list (6.6% response rate) and 163 responses from the anonymous link, for which the response rate could not be calculated. Demographic information shows that the majority of respondents (67%) were between 35 and 64 years old, with 81% identifying as male and 78% as white or Caucasian (supplementary table 1). Demographic differences did not have a large impact on results. Most of the respondents were from counties located in the Central Valley, where the majority of agronomic crops are grown (fig. 1A). Respondents included growers, consultants, allied agricultural industry personnel, and others involved in agronomic crop production in California (fig. 1B). Agronomic crops represented around 60% of total acreage in farming operations managed by respondents, with the remainder in vegetable and tree and vine crops. Five agronomic crops accounted for almost half of responses. These were rice, alfalfa, wheat (grain), corn (grain), and corn (silage) (fig. 2). Dry bean, cotton, sunflower, barley, triticale, and small-grain silage accounted for another quarter of total responses.

Priorities and satisfaction

We used a Likert scale to measure stakeholder views on priority and satisfaction regarding different topics for agronomic crop production for which UCCE has research and outreach delivery. All participants were given a list of 19 topics and asked to select whether these topics were of "high priority," "medium priority," "low priority," or "no opinion." The 19 topics (in alphabetical order) were: compost management, cover crops, crop establishment, disease control, emerging crops, greenhouse gas (GHG) emission reductions, harvest/

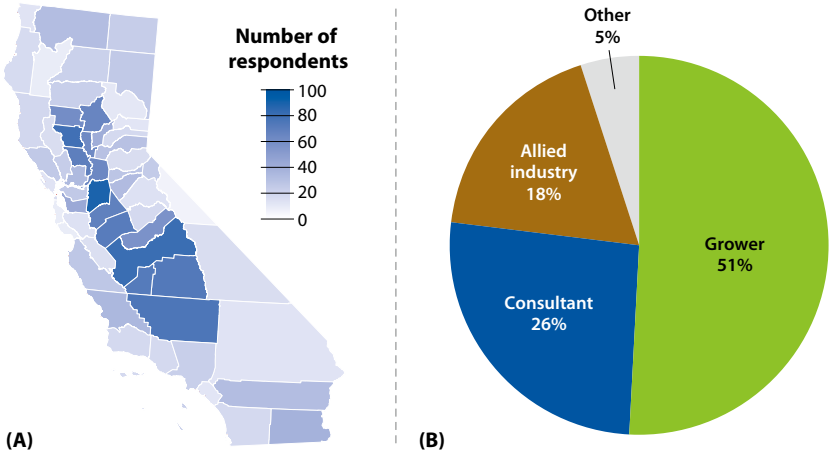

FIG. 1. Number of survey respondents operating in each county in California (A). Proportion of survey respondents that were growers, consultants, allied industry, and other (B).

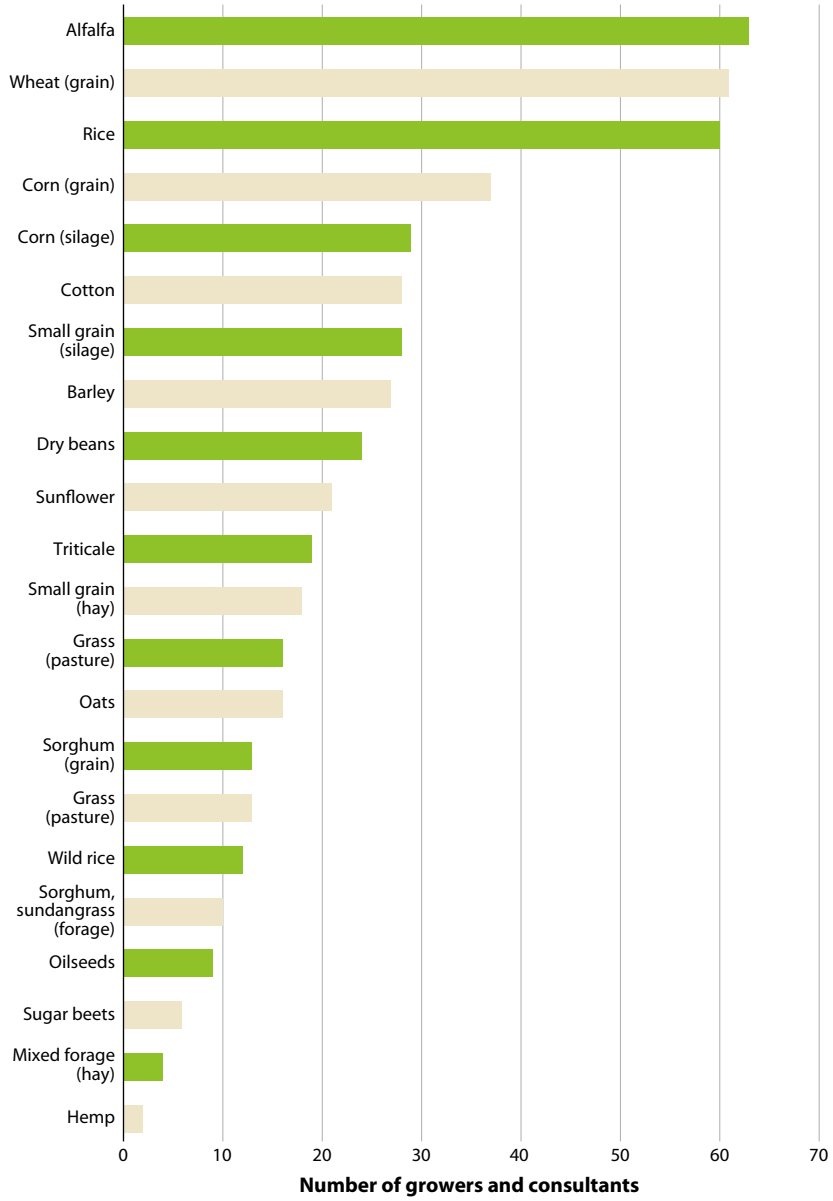

FIG. 2. Agronomic crops managed by growers and consultants in the survey.

postharvest, insect pest control, irrigation management, manure management, niche marketing, nutrient management, organic production, salinity management, soil health management, testing new products, variety testing, water conservation and storage, and weed control. With the same list of topics, respondents were asked to rate how satisfied they were with UCCE's delivery of information on these topics ("high satisfaction," "medium satisfaction," "low satisfaction," or "no opinion"). High priority and satisfaction were given a score of 3, medium priority and satisfaction were given a score of 2, and low priority and satisfaction were given a score of 1. No opinion was treated as no response. Scores for priority and satisfaction were averaged across all stakeholder groups (i.e., growers, consultants, and allied industry professionals) and plotted on figure 3, with priority on the y-axis and satisfaction on the x-axis. A 95% confidence interval for the mean for each topic was calculated based on the standard deviation and sample size, assuming a normal distribution.

To understand needs that can be addressed through research and extension, we used the IPA methodology. The IPA is a quantitative approach for measuring how people feel about certain issues by generating a diagram of how important specific topics are to respondents, compared to their level of satisfaction on those topics (Martilla and James 1977; Warner et al. 2016). We developed a Warner diagram to illustrate needs based on topics falling into one of four quadrants (Warner et al. 2016). The four quadrants represent the different combinations of priority (high vs. low) and satisfaction (high vs. low). Boundaries of each quadrant are defined by the averages of priority and satisfaction across all topics. Each quadrant has a different interpretation, which is summarized on figure 3 to aid interpretation of results.

Interpreting results

Traditionally, IPA results are used to identify topics located in the high priority–low satisfaction quadrant, which suggests that information needs are not being met by current programs. Because low satisfaction indicates the need to prioritize these topics with greater resources and effort, we have labeled this quadrant "Improve information delivery." In contrast, there are two low-priority categories: low priority–low satisfaction and low priority–high satisfaction. In theory, resources can be allocated away from these topics to address higher priority issues. Consistent with previous work, we have labeled the low priority–low satisfaction quadrant as "Low interest to target audience" and the low priority–high satisfaction quadrant as "Reconsider information delivery efforts, re-assess priority later," respectively (Levenburg and Magal 2004; Martilla and James 1977; Siniscalchi et al. 2008). Finally, focus should remain on topics that fall into the high priority–high satisfaction quadrant because these represent important issues for clientele, and current UCCE programs appear to be meeting information needs for these topics. We have labeled this quadrant "Maintain focus on these issues." In this way, the division of topics into four different IPA quadrants can be used to help prioritize research

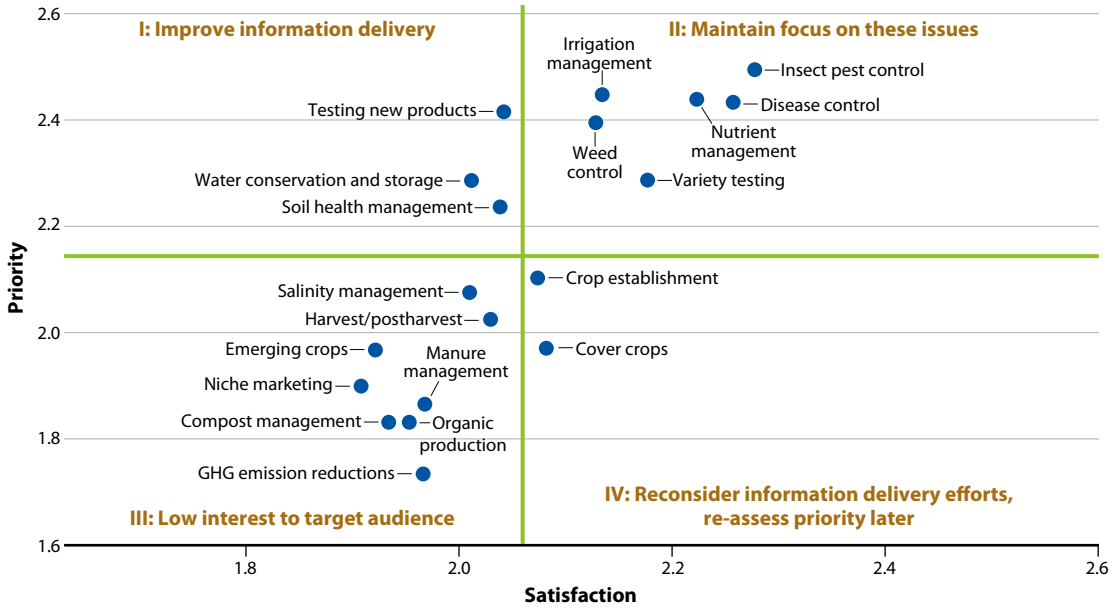

FIG. 3. Importance-Performance Analysis showing priority and satisfaction scores ranked by survey participants for each agronomic topic. Scores were calculated based on numeric ratings of 1, 2, and 3 representing low, medium, and high priority or satisfaction. The green horizontal and vertical lines represent the mean priority and satisfaction scores across topics (2.14 and 2.06, respectively).

and extension activities (Levenburg and Magal 2004; Siniscalchi et al. 2008).

A final question on the survey was open-ended and gave stakeholders the opportunity to share ideas they had for applied research and extension. Responses were categorized into seven interest areas: water resources and management; soil and nutrient management; pest, disease, and weed management; varieties and breeding; technology; production, processing, and marketing; and grower concerns. To systematically present these results while preserving the original intention and language of respondents, we have included a full list of categorized responses in the online supplementary information. These qualitative statements are not presented in the results section, but are used in the discussion section to provide context and support interpretation of the quantitative IPA results. Open-ended responses were summarized to better understand stakeholder interests within the broader topic areas identified as high or low priority in our study.

High and low priorities

The percentage of respondents ranking topics as high, medium, or low priority varied considerably (table 1). The same was true for satisfaction scores (table 2). The mean for each topic ranged from 1.73 to 2.49 for priority and 1.91 to 2.28 for satisfaction. Confidence intervals can be used to compare priority and satisfaction scores within a topic or against the mean priority or satisfaction score across all topics. The mean priority score for respondents was 2.14, while the mean satisfaction score was 2.06 (green lines, fig. 3). The confidence intervals for crop establishment and salinity management were the only ones that overlapped with the mean priority score. Confidence intervals overlapped with the mean satisfaction score for cover crops, crop establishment, harvest/postharvest, salinity management, soil health management, testing new products, and water conservation and storage. In figure 3, topics ranked high priority by respondents are plotted in the upper two quadrants, with topics having lower satisfaction in the left quadrant and higher satisfaction in the right. Topics plotted in the lower two quadrants of the diagram are of lower interest to respondents.

Stakeholders indicated that the following topics were high priority and had above-average scores for satisfaction of information delivery: weed control, irrigation management, nutrient management, disease control, insect pest control, and variety testing. This puts them in the category of "Maintain focus on these issues."

High-priority topics for which satisfaction scores were below average ("Improve information delivery") include testing new products, soil health management, and water conservation and storage. Within each of these three topics, the priority confidence interval did not overlap with the satisfaction confidence interval, indicating higher priority than satisfaction.

TABLE 1. Percentage of respondents that ranked research and extension topics as high, medium, or low priority

Topic	High priority (%)	Medium priority (%)	Low priority (%)	Mean	Confidence interval
Insect pest control	54.9	35.2	7.0	2.49	2.43–2.56
Irrigation management	51.6	39.2	7.5	2.45	2.38–2.51
Nutrient management	50.6	38.6	7.9	2.44	2.37–2.50
Disease control	54.0	31.3	12.1	2.43	2.36–2.50
Testing new products	53.1	32.7	12.6	2.42	2.34–2.49
Weed control	49.6	36.0	11.6	2.39	2.32–2.46
Variety testing	43.1	36.6	15.8	2.29	2.21–2.36
Water conservation and storage	43.4	37.2	16.0	2.28	2.21–2.36
Soil health management	40.2	39.7	17.3	2.24	2.16–2.31
Crop establishment	31.9	41.0	22.5	2.10	2.02–2.18
Salinity management	31.2	40.5	24.2	2.08	2.00–2.15
Harvest/postharvest	25.2	45.7	22.9	2.03	1.95–2.10
Cover crops	25.5	42.3	28.4	1.97	1.89–2.05
Emerging crops	23.0	42.1	26.4	1.97	1.89–2.04
Niche marketing	23.6	36.5	33.2	1.90	1.82–1.98
Manure management	17.2	42.9	29.6	1.86	1.79–1.94
Compost management	18.9	38.3	35.0	1.83	1.75–1.91
Organic production	19.1	38.7	34.8	1.83	1.75–1.91
GHG emission reductions	18.5	31.6	43.2	1.73	1.65–1.81

To calculate the mean for each topic, high priority was given a score of 3, medium priority 2, and low priority 1. Note, the percentage of respondents with "no opinion" is not shown, hence values do not add to 100. A 95% confidence interval was calculated for each mean. The average priority score across all topics was 2.14.

TABLE 2. Percentage of respondents that ranked their satisfaction with delivery of information for research and extension topics as high, medium, or low

Topic	High satisfaction (%)	Medium satisfaction (%)	Low satisfaction (%)	Mean	Confidence interval
Insect pest control	35.2	45.5	10.1	2.28	2.21–2.34
Disease control	34.0	44.1	11.1	2.26	2.19–2.32
Nutrient management	29.7	51.7	9.5	2.22	2.16–2.28
Variety testing	24.0	42.6	20.3	2.18	2.11–2.25
Irrigation management	26.8	49.2	14.6	2.14	2.07–2.20
Weed control	20.4	45.3	19.4	2.13	2.06–2.20
Cover crops	22.1	46.4	15.4	2.08	2.01–2.15
Crop establishment	19.2	47.9	13.3	2.07	2.01–2.14
Soil health management	16.3	45.9	15.5	2.04	1.97–2.11
Testing new products	22.4	46.1	19.0	2.04	1.97–2.11
Harvest/postharvest	18.7	45.2	16.3	2.03	1.96–2.10
Salinity management	3.1	18.8	14.6	2.01	1.94–2.08
Water conservation and storage	28.9	42.7	13.8	2.01	1.94–2.08
GHG emission reductions	13.8	39.7	16.1	1.97	1.90–2.03
Manure management	13.6	42.3	15.9	1.97	1.90–2.03
Organic production	15.8	38.3	19.3	1.95	1.88–2.02
Compost management	15.3	37.4	20.0	1.93	1.86–2.01
Emerging crops	12.0	41.5	17.6	1.92	1.85–1.99
Niche marketing	13.0	37.2	19.4	1.91	1.84–1.98

To calculate the mean for each topic, high satisfaction was given a score of 3, medium satisfaction 2, and low satisfaction 1. Note, the percentage of respondents with "no opinion" is not shown, hence values do not add to 100. A 95% confidence interval was calculated for each mean. The average priority score across all topics was 2.06.

Topics having below-average scores for both priority and satisfaction for UCCE program activities ("Low interest to target audience") included salinity management, harvest/post-harvest issues, compost management, organic production, manure management, GHG emission reductions, emerging crops, and niche marketing. In this quadrant, GHG emission reductions was the only topic where priority and satisfaction confidence intervals did not overlap. For the final quadrant, cover crops and crop establishment were also ranked as lower priority, but there was high satisfaction with UCCE work on these topics, placing them in the "Reconsider information delivery efforts, re-assess priority later" category. However, the confidence intervals for priority and satisfaction overlapped for both of these topics.

The results presented in this paper are at the aggregated level, but additional IPA results for key crops and regions are presented in the supplementary information. Moreover, to enable groups working in extension and other decision-makers to view the results most relevant for them, an interactive website displaying the survey results was created. On this website, users can filter responses to all survey questions by vocation (grower, consultant, or allied industry), crops grown, or region.

Importance of agronomic crops

Agronomic crops are vital to California agriculture, providing farm profitability as well as flexibility in adapting to different soil and climate conditions. For example, the annual nature of most agronomic crops allows growers to fallow ground in drought years; other crops, such as alfalfa, can be grown under deficit irrigation (Orloff et al. 2015). Some, such as sugar beet and durum wheat, have high salinity tolerance (Katerji et al. 2000; Maas 1993; Steppuhn and Raney 2005). Others, such as rice, are produced in flood-prone areas or regions with high water tables (Dar et al. 2013; Grimes et al. 1984; Hopmans et al. 2002). Some, such as barley, have high frost tolerance (Angessa and Li 2016). In addition, agronomic crops help address pest, disease, and weed management challenges through crop rotations (Liebman and Dyck 1993; Rusch et al. 2013). Nitrogen-fixing crops, like alfalfa and dry beans, can also contribute to healthy soils (Long et al. 2014; Meyer et al. 2007).

Despite these benefits, permanent tree crops are replacing agronomic crops in California, resulting in a loss of production flexibility and associated benefits. Since 2010, acreage planted to agronomic crops has declined by almost 30%, with a corresponding shift towards almonds, pistachios, and walnuts (CDFA

2023; USDA NASS 2024). Rice acreage remains stable despite reduced acreage during drought years, but corn, forage crops, and wheat show the greatest loss in acreage (CDFA 2023). Drivers of this decline include low commodity prices, higher land values, higher inputs costs, and higher returns from fruit and nut crops (UC ANR 2024a).

This shift in production presents an increased problem for adapting to climate change, with increased droughts in California. This is because tree crops, unlike agronomic crops, cannot be fallowed. It is likely that agronomic crops will play a larger role in California agriculture, especially in the southern San Joaquin Valley, as part of an adaptation strategy to cope with more restricted water availability. For example, research is exploring the potential of winter wheat grown with minimal irrigation to provide economic and ecosystem benefits as an alternative to land fallowing (Peterson et al. 2023). These survey results will help provide policymakers and agricultural extension agencies the necessary information to continue addressing topics that are vital for sustainable food, feed, and fiber production in California.

Quadrant I: More focus needed

We now turn to the four quadrants, starting with topics that respondents considered more important and needing more attention.

Water conservation and storage

Water conservation and storage, ranked in quadrant I, indicates that UCCE should focus more on this topic. UCCE has a long history of improving water use efficiency in agronomic crops, including subsurface drip irrigation, deficit irrigation, and groundwater recharge (Dahlke et al. 2018; Hutmacher et al. 2014; Taylor et al. 2014; Zaccaria et al. 2017). As increased regulations are challenging farmers to meet new standards, including the Irrigated Lands Regulatory Program, Dairy Order, and the Sustainable Groundwater Management Act (Ayars et al. 2015; Dettinger et al. 2011), more work is needed to understand the implications of alternative water management practices and how they can be implemented widely. Water quality and quantity continue to represent key challenges for California farmers, especially with predicted increased precipitation variability due to climate change, resulting in more droughts and floods (CA DWR 2019).

To address these concerns, stakeholders seek additional information from UCCE on when to irrigate in season to optimize crop production when water supplies are limited. They are interested in drought-tolerant crops and whether groundwater recharge results in nitrogen leaching. They also seek information on topics that bridge water and soil management, including how to improve soil water-holding capacity and how the amount of applied water may influence soil health. Continued work in water management is clearly needed as California faces greater water restrictions, higher water costs, evolving markets and opportunities for water trading, and new regulations designed to address groundwater overdraft.

Soil health management

Soil health management also ranked in quadrant I as high priority and below-average satisfaction. University research documents that heathy soils improve fertility, water infiltration, carbon sequestration, and water-holding capacity (Basche and DeLonge 2019; Mitchell et al. 2015; Mitchell et al. 2017; Tautges et al. 2019). Thus, soil health management, including building soil organic matter and maintaining good structure, may stabilize crop productivity and increase resilience to stresses induced by climate change (Li et al. 2019). Stakeholders are interested in information on crop rotation impacts on soil health, in addition to long-term nutrient management strategies. In addition, they are interested in soil microbiology and invertebrate communities, as well as long-term no-tillage studies for impact on soil health.

To help address such needs, UC ANR hired 10 climate-smart agriculture community education specialists to provide assistance on Climate-Smart Agriculture Incentive Programs, in partnership with the California Department of Food and Agriculture (CDFA) and Strategic Growth Council, starting in 2019 (Yount 2021). These include the Healthy Soils Program (HSP), the State Water Efficiency and Enhancement Program (SWEEP), and the Alternative Manure Management Program (AMMP), which provides funds to livestock producers who decrease their methane emissions by changing the way they manage manure. Additional academic advisors and specialists are needed to help showcase the impacts of these programs on soil health.

New products and technologies

UCCE collaborates with growers and industry to objectively determine the economic benefits of new products and technologies in crop production. In the survey, respondents expressed particular interest in UCCE testing new products for pest management; they value when UCCE tests alternatives to products like the recently banned insecticide chlorpyriphos. Respondents also seek information on plant phytotoxicity data, preventing pests from becoming resistant to available chemicals, and new methods of pest management in organic production. Survey comments also indicated a role for UCCE in testing new technologies; respondents wished to see more research and extension activity on irrigation automation, drones, and remote sensing. They indicated that new technologies are needed to address higher input costs and shrinking labor supplies.

Survey respondents named variety testing as a high priority. UCCE offers field days for growers, consultants, and industry to view on-farm variety evaluations. *Photo*: UC Cooperative Extension.

Quadrant II: Keep the focus

Pest management

Based on survey results, pest management disciplines are high priorities for agronomic crop production because pests impact crop yield and quality. Though respondents gave high rankings to their satisfaction with UCCE's activities around pest management, ongoing attention is needed on this topic, because pest management issues are dynamic. Key issues include pest resistance to available chemistries (Hanson et al. 2014), fewer chemicals coming to the market, high pesticide costs, and new and invasive species that are challenging to control (Funk et al. 2014; Osipitan et al. 2021). Stakeholder interests included the development of pest density thresholds at which management action should be taken, experimenting with cultural practices as alternatives to chemicals, organic methods of pest control, and pesticide rotation for managing pest resistance. Additionally, respondents desired information on different types of additives for increasing chemical effectiveness, issues of chemical incompatibilities in mixtures, and hands-on experience in calibrating spray equipment. Localized, applied research is needed to develop and implement practices to manage endemic and invasive pests in agronomic crops.

UCCE is working on solutions to address these complex challenges. Critical to developing solutions is having personnel in key positions. For example, UC ANR has supported disease and entomology specialists for agronomic crops with little interruption from retirements. Entomology advisors, however, have retired from California's Central and Imperial valleys, and these positions have not been filled. A lack of weed control expertise in UCCE is due to recent retirements and attrition (e.g., staff consolidation or turnover), as well as organizational decisions not to rehire in this area due to budget limitations. For example, the agronomic weed management specialist retired in 2013, and the position has only recently been prioritized for recruitment by UC leadership. Meanwhile, industry is less likely to support pest management research in agronomic crops compared to higher value crops, such as trees and vines. Thus, hiring pest management specialists and advisors would help respond to evolving challenges and support extension in developing practices to manage endemic and invasive pests in agronomic crops.

Nutrient management

Nutrient management, particularly nitrogen, is critical to maintaining agronomic crop profitability while also sustainably managing environmental resources. Nitrogen use efficiency was identified by stakeholders as a topic where UCCE should continue to focus resources, perhaps due to new regulatory programs that monitor farmer nitrogen use, such as the Irrigated Lands Regulatory Program (ILRP). Stakeholders also expressed interest in nutrient management when using compost and manure, organic fertilizers, and micronutrient management in different soil textures. Ongoing work is needed to better understand how organic soil

amendments impact nutrient dynamics in different environments. The satisfaction of respondents with UCCE delivery of information in the area of nutrient management may be attributed to UC ANR support for a nutrient management specialist, and CDFA grant support through the Fertilizer Research and Education Program (FREP).

Variety testing

The university supports variety developments in agronomic crops like alfalfa, wheat, rice, and dry beans, and UCCE specialists and advisors conduct statewide trials in these and other agronomic crops, including rice, corn, and cotton. Trials are conducted on university campuses, UC ANR Research and Extension Centers, and on private farms to provide information for varying climate and soil conditions. These trials are often showcased to industry through annual field days and are financially supported by the California Crop Improvement Association, commodity boards, and industry groups, highlighting how public-private partnerships can serve as a platform for effective research and outreach. While stakeholders value UCCE program delivery in variety testing, they expressed interest in expanded programming, particularly in organic systems or in evaluating crops for multiple uses, including grains and forages.

Quadrants III and IV: Lower priorities

The IPA framework helps specify where gaps in priority and satisfaction exist, based on current challenges and industry needs, which often relate to shorter-term management decisions and financial pressures. On the other hand, some topics ranked as lower priority may not have immediate consequences but are still key to addressing broader environmental or social goals in California agriculture. Therefore, while UCCE resources and programming should be focused on the high-priority topics related to on-farm crop production that were identified in this survey, attention will also be needed on lower-priority topics to address long-term challenges, either through existing UCCE programs or new partnerships with other organizations. Our findings highlight the need to use creative research and extension approaches to engage and educate the agricultural sector about important topics that they perceive as less important.

For example, GHG emission reductions, cover crops, organic production, manure management, and compost management were of low interest to stakeholders, despite environmental and regulatory pressure to address these topics. California state law AB 1826 ramps up green and food waste recycling requirements across the state, resulting in larger proportions of organic waste streams being processed into compost. Municipalities are seeking end uses for this compost to cope with incoming waste volumes. Agronomic crops could benefit because compost application is a soil health-building practice (Brown and Cotton 2011; Gravuer et al. 2019). Another state law, the Global Warming Solutions Act (AB 32), establishes a comprehensive program to reduce GHG emissions from all sources throughout the state, including agriculture. Lack of interest in GHG emission reductions from the agronomic industry could be due to farmers getting information from other sources, like the CDFA's Healthy Soils Program or local Resource Conservation Districts, or because of a lack of familiarity with UCCE program activities in this area. The role of UCCE in developing and extending local, science-based information is critical to addressing these statewide issues.

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Niche marketing and emerging crops ranked low on both priority and satisfaction by survey participants, despite growing consumer interest and demand for new and sustainable food choices. Examples of such crops include wild rice, malting barley, hemp, and heirloom beans. Lack of stakeholder interest could be due to the relatively small number of specialty agronomic crops. An agronomy cropping systems specialist is needed to develop information in this area. Also, linking into the UC Davis Smart Farm Program might provide additional information for individual needs on crop establishment and harvest/post-harvest technology issues.

Building on strengths

The survey results pointed to areas where extension should continue its efforts, as well as areas that need more attention and resources.

Address local issues

California agriculture faces many challenges related to farm economics, water scarcity, shifts in market demand, labor availability, environmental regulations, and natural resource conservation. In this dynamic context, this needs assessment represents a cost-effective approach for empowering organizations to better understand and address stakeholder priorities. Participation and engagement from UCCE specialists and advisors from the beginning drew on their subject-matter expertise and made the most of limited resources. Collaboration across teams helped address shared goals within UCCE more efficiently. Growers and other stakeholders piloted the survey and provided extensive feedback, building in participatory and culturally responsive elements of this study that helped ensure that questions were valid and results were usable. Partner organizations played a key role in disseminating the survey beyond current UCCE networks, expanding the outreach through other government and industry channels.

Events such as the UC Davis Small Grains and Alfalfa Field Day highlight how public-private partnerships can serve as a platform for effective research and outreach. *Photo*: Evett Kilmartin.

Research and extension programs must be based on local needs, including regional crops and environmental concerns evidenced through grower consultations and evolving state conservation and regulatory programs. As expected, survey results varied by crop and production region in California (online supplementary information). On a local level, it is critical to consider these differences when taking steps to improve extension programs for maximum impact, while also developing other forms of needs assessments and expertise to identify high-priority topics.

Some high-priority topics had significance in particular crops and regions but not others. For example, salinity management, which ranked in quadrant III as a lower-priority topic overall, was ranked as a high priority for growers located in the Imperial and San Joaquin valleys, where salts pose a significant challenge for crop production (online supplementary information). Additional work is needed on managing salts, especially in light of predicted droughts affecting water availability for leaching salts below the root zone. The Salinity and Drainage Program through UC ANR's California Institute for Water Resources should reactivate and continue to focus efforts on salinity management issues (UC ANR 2024b).

Another example is that soil health management was not identified as a topic for "Improve information delivery" (quadrant I) for alfalfa or rice, but it was for wheat and cotton. Soil health issues may be more apparent in annual crops compared to flooded rice or perennial forages with minimal soil disturbance and deeper rooting systems. Also, irrigation management for cotton stood out as a topic of high priority that needs more attention. However, for other crops, this topic tended to fall in quadrant II ("Maintain focus on these issues").

Gathering stakeholder input on the importance of different topics and the extent to which information needs are met by current resources has broad implications for those working in research and extension. The website displaying survey results provides a resource to understand how priorities may differ by crop and region, helping UCCE personnel to tailor their programs to the most relevant concerns while integrating these priorities with other sources of knowledge and information to achieve local impact. At a broader scale, results can guide decisions on how to direct resources and funding, ensuring the relevance and impact of future efforts.

Necessary changes

These results are timely for policymakers who manage institutional, regulatory, and funding programs supporting agronomic crop production in California, a vital industry. The top priorities identified by stakeholders directly impact on-farm crop production, while lower-priority issues highlight the need for greater engagement and education. As UC ANR rebuilds UCCE academic programs with a recent state budget augmentation, evidence from this study can be used to provide recommendations for directing resources to improve research and extension efforts. Such insights will help turn these survey results into actionable information and enhance the impact of UC ANR and public funding programs. The following recommendations provide potential paths forward to extend science-based information on agronomic cropping systems, helping meet the needs of producers and industry in California.

1. Investment in academic personnel is imperative to rebuild programs lost during budget cuts of the past 20 years. In UC ANR's staffing analysis, agronomy and cropping systems had the highest advisor priority needs of all the statewide programs (UC ANR 2021). Critical positions are needed in core agronomy programs that also represent high-priority needs as identified in this study, including integrated pest management, nutrient management, healthy soils, and irrigation management.

2. From 2018 to 2020, an estimated 33 advisors and one specialist resigned from UC ANR. Reasons for leaving included inadequate new employee trainings, and insufficient financial resources to conduct research and outreach with growers, agricultural industry, and other researchers. Job expectations are also too high for personnel serving multiple counties (Academic Assembly Council, personal communication). Mentoring and support for new academics are critically needed, with a focus on establishing links with growers and industry leaders working in high-priority topic areas.
3. Advisors need centralized support, including personnel and equipment, for county-based programming. Permanent county-based technical agricultural field staff would enable advisors to maintain robust research and extension programs. In addition, equipment for planting, maintaining, and harvesting agronomic crops on research plots — and staff to maintain and operate the equipment — would improve the efficiency of field research. The equipment could be shared among UC agronomy academics, who are networked through UC ANR Program Teams. This will ensure that field research activities are capable of addressing high-priority issues.
4. Funding opportunities should cover longer time periods to generate impact. For example, the CDFA Healthy Soils Program supports UCCE projects that demonstrate cover cropping, compost amendment, and GHG emission reductions, among other practices. Lengthening research funding timelines would create larger datasets that could better demonstrate meaningful outcomes. Research contracts are often one to three years in length, but that may not be enough time to observe important results for slow biological processes related to insect, disease, and weed control or soil health, where the benefits of practices could take years to become apparent.
5. Where incentive grants support on-farm practice implementation, public databases should be developed to report aggregated statistics regarding the adoption of different types of management practices stemming from outreach and extension efforts. For example, the acreage of implementation under an alternative nutrient management practice could be reported by county, as is done with annual crop reports and pesticide use. Such databases would help improve our understanding of which types (or topics) for research and extension are having the biggest positive impact on California agriculture.

Future implications

As extension programs nationally and in California face growing needs, the collaborative approach used here serves as an example for teams of experts to work together in engaging stakeholders, gathering input, and setting priorities. Our findings can be used by agricultural extension and universities more broadly, as well as by state and federal agencies and local government working on these topics.

Our results indicate that UCCE is meeting clientele needs on high-priority topics such as integrated pest management, nutrient management, variety testing, irrigation management, and testing new products. However, based on open-ended responses, clientele want more information on these topics. UCCE is poised to deliver this information through research and extension. To address high-priority issues, institutional and financial support is needed to maintain the UCCE academic footprint and programming in agronomic cropping systems. Meanwhile, areas identified as low priority are still critical topics for sustainable agriculture in California and reflect a need for UCCE to engage farmers in a way that connects with current challenges they face and connects these topics to their bottom line of farm profitability.

Needs assessments are an ongoing process, and these results should be integrated with other efforts to guide UC ANR organizational and resource allocation decisions, helping maximize the impact of research and extension programs for agronomic crop production in California. CA

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