



Final Report: Summative Evaluation of the Completed Next Generation Crops Grants

Prepared for

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Executive Summary

The Foundation for Food & Agriculture Research (FFAR) funded a portfolio of research projects under the Next Generation Crops investment portfolio between 2017 and 2024. These projects covered a wide range of topics related to crop improvement and related topics, ranging from upstream seed development to downstream management practices. FFAR contracted RTI International, a nonprofit research organization, to complete a summative evaluation of a subset of Next Generation Crops investments that completed their period of performance by December 2024 (**Table E-1**). The portion of the portfolio that RTI reviewed consisted of 17 grants, representing a total of \$9.9 million of FFAR funding.

The purpose of the evaluation was to evaluate the success of the completed projects within the Next Generation Crops portfolio, capturing projects' outputs, outcomes, and, where available, impacts. To accomplish this, the summative evaluation included two complementary elements: one was a review of aggregate, high-level results achieved by the program, and the second was a deep dive into two "exemplars," or in-depth case studies. These exemplars included a deeper look at specific project achievements of the work accomplished under the portfolio and a quantitative accounting of the economic benefits of the investments.

The subset of Next Generation Crops projects evaluated were successful in advancing research across a range of topics over a fairly short period of time. The organization's investment of \$9.9 million was able to attract significantly more resources from matching, concurrent, and follow-on funding from a mix of sources, including \$9.3M in matching, \$5.9M in additional concurrent funding, and \$23.6M in follow-on funding, adding up to total research funding of \$48.6 million. The portfolio covered a variety of topics, focusing on 11 crops and leading to 24 innovations. These innovations significantly advanced with respect to FFAR's Research, Development, and Deployment (RDD) stages, led to six patents being submitted, and one patent reaching the approval stage at the time of this report. In terms of advancing research, projects directly led to more than 150 peer-reviewed publications, including 3,649 collective citations, 26 policy citations, and more than 250 recorded public disseminations.

Table E-1. Overview of evaluated projects within the Next Generation Crops portfolio

Metric	Value
No. of awarded grants	17
FFAR research funding	\$9.9M
Total research funding, all sources	\$48.6M
Avg. length of funding	3 Years, 5 Months, 22 Days
No. of crops	11
No. of innovations	24
Average change in RDD* (Proposal – Project End)	2.7
Average change in RDD* (Proposal – Present)	4.0
Number of publications	153
Number of policy citations	26
Number of citations in the literature	3649
Number of public disseminations	255
Number of approved patents	1

*RDD: Stages of Research, Development, and Deployment

Given the wide range of topics addressed by FFAR under the portfolio, to give focus to the work, RTI focused on three related research questions that would guide the evaluation.

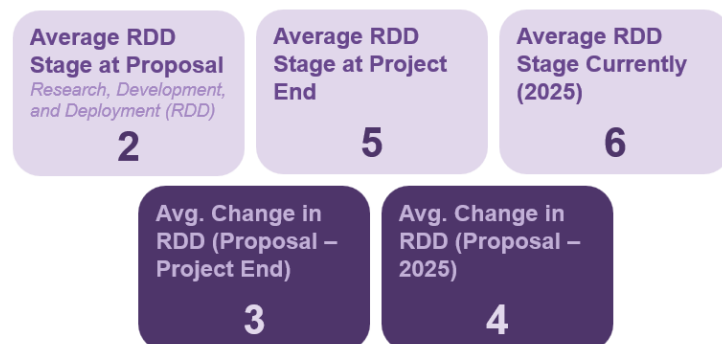
- 1) *To what extent did the portfolio advance research, expand knowledge, and accelerate innovation for target crops? Within which categories were these advancements made?*

There is significant evidence that FFAR advanced research, expanded knowledge, and accelerated innovations across a range of crops. FFAR supported at least 24 innovations across the 17 projects, including a mix of methodologies, technologies, and practices. Investments were spread across a diverse agricultural portfolio, with efforts explicitly advancing innovations across 11 traditional and non-traditional crops. Projects addressed several distinct technical advancement categories, with nearly all focused on increasing productivity. The next most common were enhancing resilience to pests and pathogens (nine projects) and reducing the use of on-farm inputs (eight projects). Projects also made strong contributions to peer-reviewed literature, where projects produced more than 150 peer-reviewed publications cited 3,649 times by the time of writing. On average, this literature was cited over twice as much as the expected number of citation for other similar research, implying that FFAR-funded publications advanced agricultural research more than its peers. FFAR grantees also disseminated their research widely across 188 conferences, but also through courses, workshops, radio, newspapers, and webinars. These numbers were all verified by the evaluation team, but should be viewed as conservative, as the team relied on available data from reports and incomplete responses to surveys.

- 2) *To what extent have Next Generation Crops innovations advanced toward commercialization (increasing the likelihood that they will ultimately be adopted by end users)?*

The evaluation found mixed success in promoting advancement toward commercialization but found strong evidence for advancement toward technology utilization. The primary metrics used to track projects' progress toward commercialization were RDD stages advancement and

Figure E-1. Average advancement in stages of RDD



patents. In terms of RDD stages, the Next Generation Crops portfolio of projects made impressive gains. They advanced by an average of about three stages from project proposal to project end, and by four stages from project proposal to the present (**Figure E-1**). Regarding patents, six projects applied for patents, but as of the conclusion of this evaluation, only one was approved.

Despite this evidence of advancement, more context is required to fully answer this evaluation question. Commercialization was often not an explicit, stated goal of the projects evaluated, and the innovations that FFAR supported sometimes advanced research broadly and often in the public sphere. However, in many cases, principal investigators (PIs) could

not or did not track next user or end user uptake nor commercialization. Additionally, a more complete analysis of advancement toward commercialization would consider factors such as development resources, inventors/team status, business strategy, and market fit.

- 3) *What is the potential that Next Generation Crops–supported crops, if commercialized, will lead to increased farm profitability? If so, what will be the expected change in profitability?*

The last research question was the most difficult to conclusively assess. Much of the funded research was upstream and/or was geared toward developing methodologies, tools, or other data products that were still a step or two away from being commercialized. Nonetheless, the evaluation team asked the PIs in the survey if data had been collected that would enable them to make an educated estimate for how much yield may increase or input usage may decrease because of the innovation(s) and to share that evidence. Translating those estimates into per acre, current dollar values showed benefits of anywhere from \$49 to \$274 in increased revenue and from \$18 to \$450 in reduced costs per acre across four projects and six crops. These benefits were not independently substantiated and would be realized years into the future but do help to provide a sense of scale in monetary terms.

To complement the research questions above, RTI conducted two deep dive analyses of exemplar projects that reflect persuasive examples of how FFAR supported two technologies expected to have concrete benefits to agri-food system actors. RTI modeled that these two projects could collectively provide approximately \$100 million in benefits to agricultural producers (**Table E-2**). One project, focused on management practices for controlling grapevine ripe rot for East Coast wine grape growers, found the FFAR investment has already led to \$7 million in benefits to vineyards and is projected to provide an additional benefit of \$37 million over the coming decade. The other project, focused on commercialization of a high-protein variety of chickpeas, has a projected impact of \$56 million for agricultural producers, and potentially more for other actors in the agri-food system.

Table E-2. Exemplars' modeled cost-benefit analysis results (US\$ thousands)

Project Title (PI Name)	Type of Benefit Accrued to Farmers (Years Modeled)	Real, Discounted Benefits	Real, Discounted Costs	Net Present Value of Benefits
Using Novel Genes from Wild Germplasm to Boost Protein Content in Cultivated Chickpea (B. Riely)	Prospective (2025–2035)	\$56,710	\$1,157	\$55,552
Developing Novel Strategies for Improved Control and Sustainability of Grapevine Bunch Rot Management (M. Hu)	Realized (2020–2024)	\$7,492	\$407	\$7,085
	Prospective (2025–2035)	\$37,598	\$407	\$37,191

These exemplars were standout successes and not reflective of the wider set of funded projects. The wide diversity in both crops and types of innovation supported by the broader

portfolio implies a tradeoff between a wider set of research outcomes versus a narrower set of breakthroughs in specific crops or technologies. Also, the upstream and research foci of investments tended to mean that projects were more geared to producing innovations that served as public goods rather than being optimized for commercialization as an end goal.

Through desktop reviews, research, and surveys, this evaluation was able to collect, standardize, and summarize a substantial amount of data and information about the achievements of a subset of Next Generation Crops projects. The portfolio performed extremely well, effectively advancing research across a diversified number of crops, generating a wealth of research outputs, and supporting different promising types of innovations that have the potential to increase benefits to farmers. However, several factors limited a full accounting of the outcomes; some projects ended years ago, PIs had often moved on to different organizations and/or had unknown updated contact information, and final reporting lacked the ability to draw out key and nuanced details. Given these challenges, it is likely that the Next Generation Crops program had greater impacts than are reflected in this evaluation.

Introduction and Background

The Foundation for Food & Agriculture Research (FFAR) funded a portfolio of agricultural research projects under the Next Generation Crops investment portfolio between 2017 and 2024. These projects covered a wide range of topics related to crop improvement and related topics, ranging from upstream seed development to downstream management practices. FFAR contracted RTI International, a nonprofit research organization, to complete a summative evaluation of a subset of Next Generation Crops investments that completed their period of performance by December 2024. The total portfolio that RTI reviewed consisted of 17 grants, representing a total of \$48.6 million.

In the request for proposals (RFP) for the evaluation, the Next Generation Crops portfolio was described by FFAR as being designed *“to solve the strains that an increasing global population, scarcity of resources, changing climate and changing consumer preferences are, and will continue to be on our current cropping systems. [The portfolio] supports the advancement of novel, nutritious, profitable and resilient on-farm crops...[with] a strong emphasis on developing new technologies to benefit consumers, producers and the environment.”*

The purpose of the evaluation was to evaluate the success of the completed projects within the Next Generation Crops portfolio, capturing projects’ outputs, outcomes, and, where available, impacts. The evaluation was intended to help FFAR understand the degree to which the projects achieved portfolio aims. To accomplish this, the summative evaluation included two complementary elements: one was a review of aggregate, high-level results achieved by the program, and the second was a deep dive into two “exemplars,” or in-depth case studies. These exemplars included a deeper look at specific project achievements of the work accomplished under the portfolio and a quantitative accounting of the economic benefits of the investments.

Given the wide range of topics addressed by FFAR under the portfolio, to give focus to the work, RTI and FFAR agreed on three related research questions that would guide the evaluation:

- 1) *To what extent did the portfolio advance research, expand knowledge, and accelerate innovation for target crops? Within which categories were these advancements made?*
- 2) *To what extent have Next Generation Crops innovations advanced toward commercialization (increasing the likelihood that they will ultimately be adopted by end users)?*
- 3) *What is the potential that Next Generation Crops–supported crops, if commercialized, will lead to increased farm profitability? If so, what will be the expected change in profitability?*

This final report discusses the high-level approach and methods to the evaluation, gives a summary and interpretation of the results according to the three research questions, notes some implications for future programming, and provides a brief conclusion. More details on

the findings and relevant background information, including the exemplar reports, can be found in the annexes.

Approach and Methods

RTI followed a mixed methods approach to the evaluation, using a combination of document reviews, a web-based survey, and targeted use of online databases; for the exemplars, these methods were complemented by close collaboration with principal investigators (PIs) and key informant interviews. RTI conducted the evaluation over a period of 7 months, meeting every 2 weeks with a core FFAR team consisting of the Monitoring and Evaluation Manager and two technical staff responsible for the Next Generation Crops portfolio. During those meetings, RTI and FFAR discussed and refined approaches, reviewed interim results, and outlined next steps. The meetings served as an important connection point to ensure the evaluation stayed focused and aligned to FFAR's needs.

RTI followed three main tasks for the evaluation, as follows.

Task 1. Kickoff, stocktaking, and evaluation framework development

This task consisted of several primary activities:

- Alignment with the FFAR evaluation team on the approach of the evaluation and understanding the background and context for the portfolio
- Review of projects' final reports
- Refinement of key research questions to guide the evaluation
- Identification of key metrics that aligned with each research question
- Establishment of criteria to select the exemplar case studies

Initially, after discussing with FFAR, the research questions were narrowed down from the five that were in the RFP to a concise list of three that were most relevant and feasible to collect data on within the available timeframe and budget. After narrowing down the research questions, RTI identified a brief list of metrics that it would focus on collecting for each question. These metrics formed the basis of the cross-project data collection and analysis and were iterated on with FFAR throughout the evaluation. **Table 1** lists the final set of questions, associated metrics, and the primary methodology used to collect those metrics.

Table 1. Priority evaluation questions with associated metrics and data sources

Evaluation Question	Metric	Data Sources
Q1: To what extent did the portfolio advance research, expand knowledge, and accelerate innovation for target crops? Within which categories were these advancements made? (e.g., increasing crop productivity; increasing crop diversity; boosting nutritional content; enhancing resilience to pests, pathogens, and extreme weather)	Advancement category	Survey, Final Reports
	Number and category of research manuscripts	
	Number and category of external knowledge dissemination engagements with next/end users and consumers	
	Number and category of policy citations from research	Overton tool
	Number of citations	Web of Science & InCites
Normalized citation index		
Q2: To what extent have NextGen innovations advanced towards commercialization (increasing the likelihood that they will ultimately be adopted by end users)?	Advancement in stages of Research, Development, and Deployment (RDD)	Survey, Final Reports
	Number and type of licensing agreements	
	Number of NextGen innovations that are likely to lead to a licensing agreement or other formal adoption	
	Number of direct to commercialization agreements	Final Reports
	Amount of private sector investment in NextGen innovations	
Number and category of intellectual property filings and approvals	PatSnap	
Q3: What is the potential that NextGen supported crops, if commercialized, will lead to increased farm profitability? If so, what will be the expected change in profitability?	Focus crops	Survey, Final Reports
	Potential increase in productivity and revenues by crop	Survey, Final Reports, Desktop Research
	Potential decrease in input use and costs by crop	

A full description of each metric and relevant details about how the evaluation team collected the data can be found in the “cross-project comparison” spreadsheet provided separately in **Annex 1**.

Task 2. Cross-project data collection and analysis

For this task, RTI collected data on each metric from final reports, selected online tools, and web-based surveys. RTI developed three separate surveys corresponding to the principal investigator (PI), the match partner, and the next/end user (See **Annexes 2, 3, and 4**). These survey tools attempted to fill gaps in data available from the final report, and RTI customized the surveys toward each specific user group. RTI programmed the surveys into Alchemer and staggered the survey campaigns, first collecting the PI responses to help inform the questions as well as the contact lists for the match partner and next/end user surveys. The surveys each collected responses for about 4 weeks, though this time varied depending on user group responsiveness. During this period, RTI and FFAR collaborated on an outreach campaign consistent of multiple emails to PIs and match partners to encourage them to fill out the survey. Expectedly, given familiarity with FFAR and the projects, the PI response rate was the highest (10/17, 59%) followed by match partners (4/10, 40%) then next/end users where names and contact information could be identified (1/6, 17%).

RTI collected data for most metrics either through a thorough review of the final reports or the survey, with the following exceptions:

- The [Overton](#) platform supported identification of policy citations for manuscripts developed under the portfolio.

- The [InCites tool](#) (by Clarivate) supported calculation of the Category Normalized Citation Impact (CNCI) for each manuscript developed under the portfolio. The CNCI is a way to compare the relative research impact of each manuscript by considering its technical field, how long since it was published, and the journal where it was published. More technical details can be found in the cross-project comparison spreadsheet in Annex 1.
- The patent tool [PatSnap](#) supported the investigation and verification of the degree to which patent application advanced under the portfolio.
- RTI conducted supplemental research on commodity prices and input costs to determine the potential profitability of each innovation based on PI self-reported advancements (for Research Question #3).

Lastly, RTI worked closely with FFAR to adapt the Technology Readiness Level (TRL) framework with customized stages of Research, Development, and Deployment (RDD) that aligned better with FFAR investments, particularly with the nuances of the Next Generation Crops portfolio. For example, RTI suggested that RDD Stage 4 be divided into Stages 4a and 4b to differentiate between field research being conducted in a “relevant” environment vs. an “operational” environment, to account for more nuanced advancements during this stage. Additionally, RTI enhanced the descriptions and provided examples of what each stage might mean for Next Generation Crops implementers. The final version of RDDs that RTI used in the analysis can be found in **Annex 5**.

To understand the degree to which projects’ advanced in RDDs, in the PI survey, respondents were asked to select the innovation’s RDD stage (1) at the beginning of the project, (2) upon completion, and (3) current, provided with the definitions and examples listed in the RDD graphic. “Do not know” and “N/A” were options, and a text box was also given for required justification. The industry partners survey asked a similar question. RTI evaluators ultimately reviewed PI survey responses (if submitted), industry partner responses (if submitted), and the final report to determine the most appropriate and accurate RDD classifications for the project. If the PI did not respond to the survey, RTI did not assign a current RDD, because there was no more current information on the research.

Task 3. Exemplar case study analysis and final reporting

For this final task, RTI conducted deep dives into the outcomes and broader impacts of two exemplar case studies from the broader portfolio. These exemplars were not necessarily meant to be reflective of the broader portfolio. Rather, the criteria that RTI agreed upon with FFAR to select the exemplars were as follows:

- The relative success that projects have had in achieving the goals across evaluation questions or are expected to have in the future.
- The complementarity of the two exemplars (e.g., representing different supply chains, geographies, or directed toward different target groups).
- The responsiveness and data provided by project teams, and the availability of those project teams to work closely with RTI over approximately 2 months.

RTI project team members reviewed each project for the degree to which they met each of these criteria and then reached out to project PIs to determine their willingness and interest in collaborating with RTI on the exemplars. From this process, two projects were selected for the exemplars:

1. *Developing Novel Strategies for Improved Control and Sustainability of Grapevine Bunch Rot Management*, led by PI Dr. Mengjun Hu; and
2. *Using Novel Genes From Wild Germplasm to Boost Protein Content in Cultivated Chickpeas*, led by PI Dr. Brendan Reilly.

For each of these exemplars, RTI developed a counterfactual scenario (i.e., expected business-as-usual scenario had the project not been funded) to enable more precise evaluation of the impacts made possible through FFAR support. The project-specific logic models RTI developed captured how FFAR support led to project achievements, and the complementary prospective analyses conducted quantitatively and qualitatively assessed the potential impacts of the projects. For the quantitative portion of the assessment, RTI developed detailed spreadsheet models to monetize the benefit of past and future adoption. RTI collected data for these analyses by working closely with project PIs, key informant interviews with third parties familiar with the investments, and extensive desk research. RTI created standalone reports for each case study, available as separate deliverables.

Results and Interpretation

The section begins with an overview with descriptive statistics of the Next Generation Crops Portfolio. A deeper dive into the specific results for each research question are described more fully in the subsequent sub-sections.

The completed Next Generation Crops portfolio of projects was successful in advancing research across a range of topics over a brief period of time (see **Table 2**). FFAR invested in 17 projects evaluated in this report which project teams implemented and completed during a 7-year period, 2017–2024. FFAR was able to increase the impact of these investments through leveraging both matching funding and non-matching contributions (i.e., external to the FFAR project funds). The organization invested a total of \$9.9 million but this attracted significantly more resources from matching, concurrent, and follow-on investments and other funding, adding up to total research funding of \$48.6 million. The average period of performance for projects was approximately 3.5 years. The portfolio covered a variety of topics, focusing on 11 crops, and leading to 24 innovations. These innovations significantly advanced with respect to FFAR's RDD stages and led to six patents being submitted, with one patent reaching the approval stage at the time of this report. In terms of advancing research, projects directly led to more than 150 peer-reviewed publications, including 3,649 collective citations, 26 policy citations, and more than 250 recorded public disseminations.

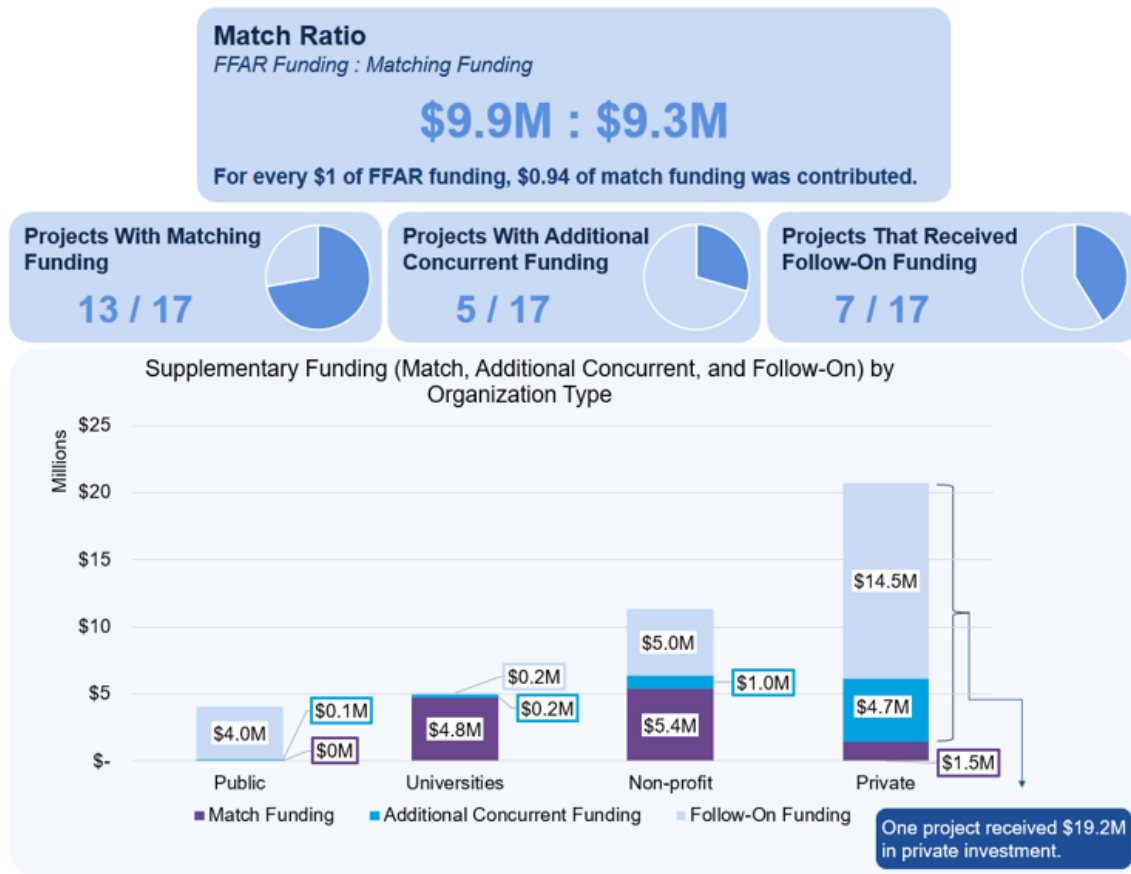
Table 2. Overview of completed projects within the Next Generation Crops portfolio**Overview of the Completed Projects Within the Next Generation Crops Portfolio**

Metric	Value
No. of awarded grants	17
Total research funding to date	\$48.6M
FFAR research funding	\$9.9M
Avg. length of funding	3 Years, 5 Months, 22 Days
No. of crops	11
No. of innovations	24
Average change in RDD* (Proposal – Project End)	2.7
Average change in RDD* (Proposal – Present)	4.0
Number of publications	153
Number of policy citations	26
Number of citations in the literature	3649
Number of public disseminations	255
Number of approved patents	1

*RDD: Stages of Research, Development, and Deployment

A key feature and differentiator of FFAR's grant programs are their matching funding requirements. Although not all the Next Generation Crops portfolio of projects had matching requirements, such as the awards under the New Innovator Award program, the portfolio was still collectively able to leverage significant matching funding, as well as concurrent and follow-on funding. This funding primarily came from a mix of private sector partners, nonprofits, and universities. Collectively, FFAR was able to leverage more than three times its investment (\$38.7 million in total for the \$9.9 million that it invested). **Figure 1** shows the leverage ratios for each type of funding and the distribution of that funding. While the more common source of funding leveraged was from universities and nonprofit organizations, the largest source was private funding (\$19.2 million), although most of that funding came from private investment in one project (chickpeas; PI: B. Riely).

Figure 1. Funding by type and source



Research Question #1: To what extent did the portfolio advance research, expand knowledge, and accelerate innovation for target crops? Within which categories were these advancements made?

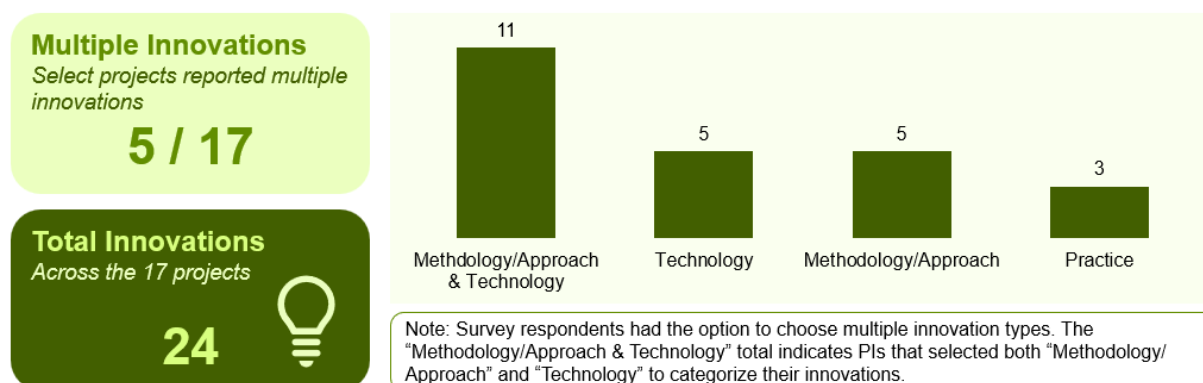
FFAR investments were well diversified, funding projects funded across several types of innovations, technical advancement categories, and a variety of crops. For innovation type, the survey asked PIs to differentiate between three types of innovations projects may have produced:

- **Technology:** Physical or digital platforms, equipment, or outputs that are developed from the application of scientific knowledge for practical or research purposes (e.g., crop varieties, a risk prediction model).
- **Methodology/approach:** A replicable procedure or set of procedures developed from the application of scientific knowledge for practical or research purposes (e.g., a more efficient way of breeding for a certain trait).
- **Practice:** An applicable set of processes, rules, or guidance developed from the application of scientific knowledge applicable to improving the effectiveness or management of agricultural work and systems (e.g., new evidence for row crop spacing).

Figure 2 provides a snapshot of the results from a review of the final reports and the survey. Although only 5 of 17 projects indicated multiple innovations, the numbers in this figure are a conservative estimate, because 7 of the 17 projects' PIs did not fill out the PI survey, which

is where they had the opportunity to distinguish between multiple innovations. The largest number of innovations a project reported was four (rice; PI: J. Leach).

Figure 2. Typology of innovations funded



A summary of how FFAR funding was divided between crops is shown in **Table 3**. In terms of target crops that were funded, projects that focused on **corn** were the most numerous (five) and received the most direct funding from FFAR (\$4.3 million), followed by **rice** (three projects, \$3.7 million in direct funding), then **sorghum**, **wheat**, and **soybean** with two projects each and FFAR funding \$2.8 million–\$3.5 million.¹ The overall picture looks different when taking into account total funding when considering matching, additional concurrent, and follow-on funding. **Chickpea** rises to the top of the list mainly because of a large infusion of private sector investment. Generally, this assessment of funding by crop type should be considered conservative; there were several innovations developed during the FFAR project that could have been applied to additional crops in the future (e.g., a CRISPR innovation tested on rice during the project but made available for genome editing any crop), but either had not been applied as of the evaluation or was not reported by PIs via the survey.

In addition to funding a diversity of crops, the Next Generation Crops portfolio contributed to a wide range of advancement categories, shown in **Figure 4**. These advancement categories reflect the types of outcomes that the FFAR Next Generation Crops portfolio was seeking to achieve. RTI collected data via the PI survey and final reports and reviewed for accuracy. The most common advancement category was "Increasing crop productivity," with 15 of 17 projects inclusive of that outcome. The next most common was "Enhancing resilience to pests and pathogens" (9 projects), followed closely by "Reduction of on-farm inputs" (8). If one assumes that "Enhancing crop diversity" is a way to increase resilience,² then the total number of projects that address some form of resilience add up to 13.³ The category addressed the least was "Boosting nutritional content," although one of those projects also leveraged more funding than any other (chickpeas; PI: B. Riely). Advancement categories by project can be found in **Annex 6**.

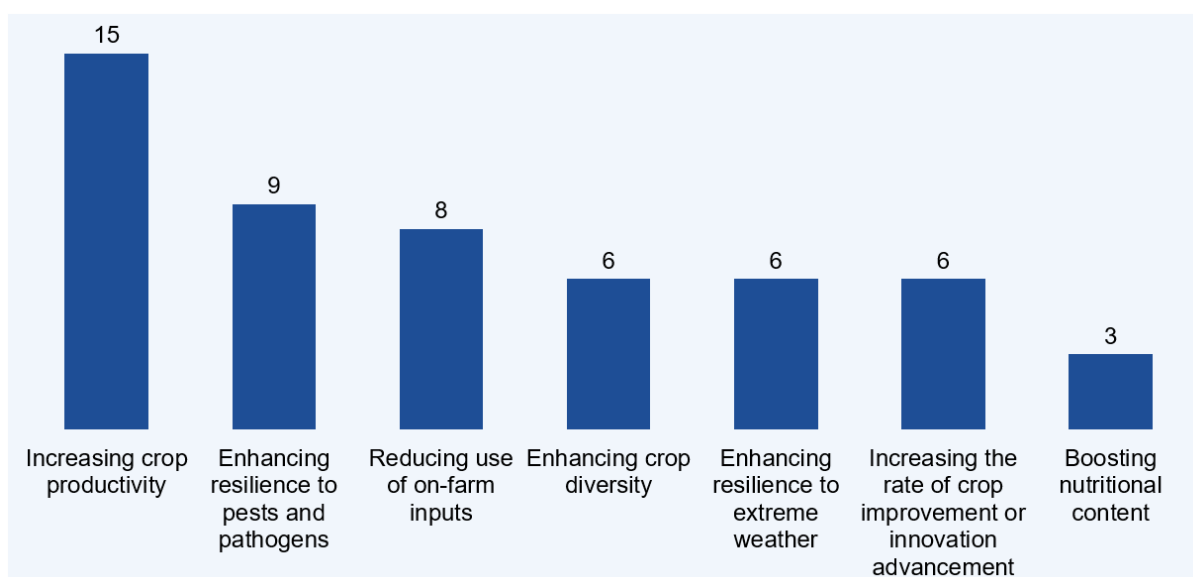
¹ Depending on the crop; if a project focused on multiple crops, the full amount of funding was applied to each crop. A fuller analysis of funding leveraged can be found under Research Question #2.

² [Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change | BioScience | Oxford Academic](#)

³ Numbers cannot be summed because projects almost always addressed more than one category

Table 3. Funding sources by crop (US\$ millions)

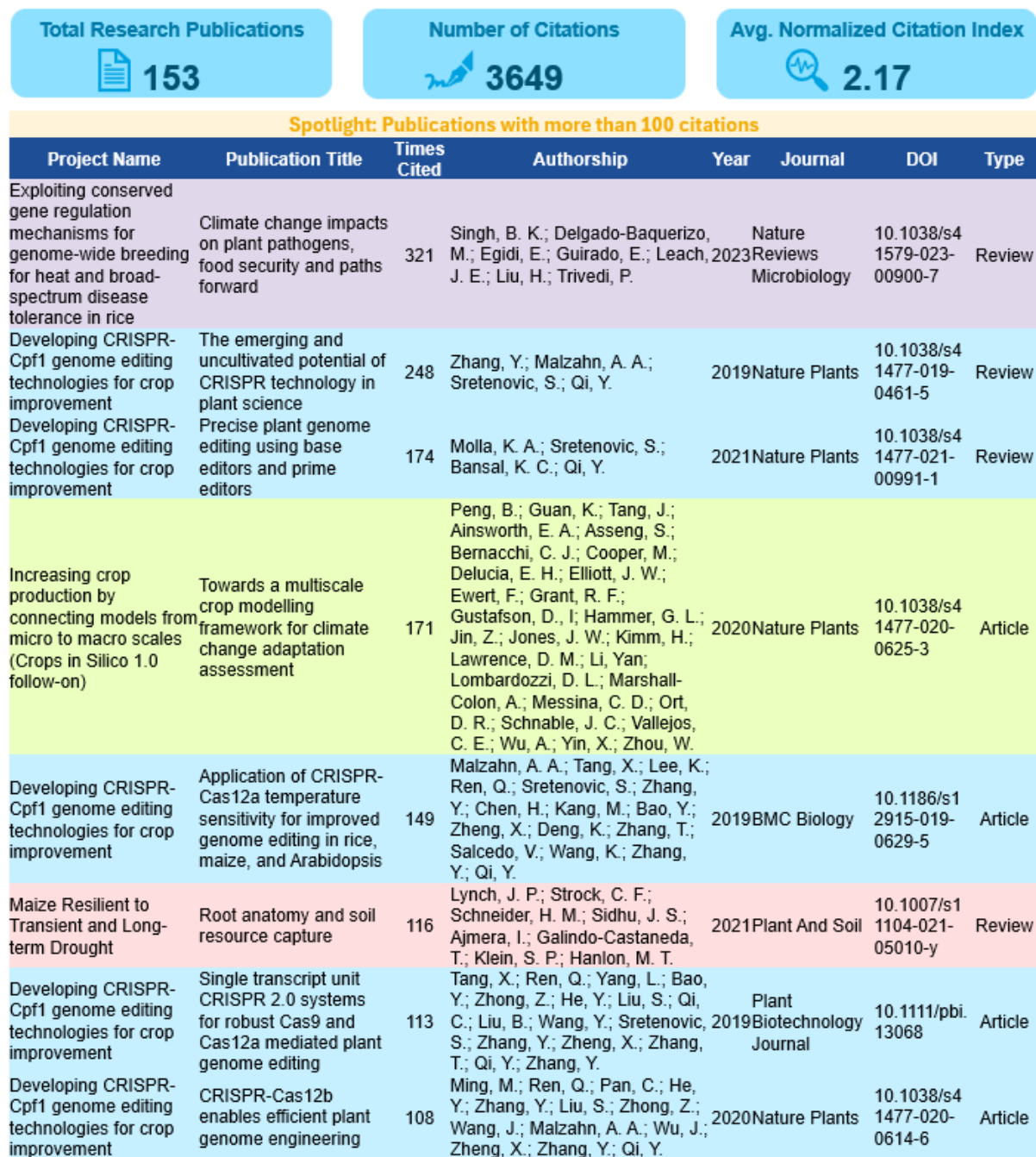
Crop	FFAR	Match	Additional Concurrent	Follow-On	Total Funding	Number of Projects
Corn	\$4.30	\$4.00	\$0.89	\$5.70	\$14.80	5
Rice	\$3.70	\$2.80	\$1.10	\$2.00	\$9.60	3
Sorghum	\$3.50	\$3.50	\$0.89	\$0.65	\$8.60	2
Wheat	\$3.40	\$4.90	\$0.89	\$0.65	\$9.80	2
Soybeans	\$2.80	\$2.80	\$0.89	\$5.70	\$12.10	2
Barley	\$2.50	\$2.50	\$0.89	\$0.65	\$6.50	1
Chickpeas	\$0.50	\$0.50	\$4.70	\$14.50	\$20.20	1
Hemp	\$0.50	\$0.50	-	-	\$0.10	1
Sunflower	\$0.45	-	-	-	\$0.45	1
Grapes	\$0.36	-	\$0.01	-	\$0.46	1
Tomato	\$0.29	\$0.29	-	-	\$0.58	1

Figure 4. Number of projects that contributed to select advancement categories

One of the key achievements of the portfolio was its overall contribution to advancing quality research. **Figure 5** summarizes research impact and highly cited papers. In total, the 17 completed projects in the Next Generation Crops portfolio produced 153 publications which peer-reviewed literature has cited 3,649 times as of time of writing. The two projects that had the most publications (52 and 23 publications) were also cited the most (855 and 1,421 times, respectively). RTI jointly used Web of Science and InCites to track citations, as well as to derive a CNCI. InCites calculates the CNCI of a document by dividing the actual count of citing items by the expected citation rate for documents with the same document

type, year of publication, and subject area.⁴ Projects that reported publications had a CNCI that ranged from 0.41 to 8.48. The average CNCI across the portfolio was 2.17, and 6 of 17 projects had a CNCI above 1.00, which indicates the project publications exceeded the average expected number of citations that were achieved by manuscripts in the same category, implying that FFAR-funded project publications have greater influence than similar non-FFAR-funded publications.

Figure 5. Selected scientific achievements

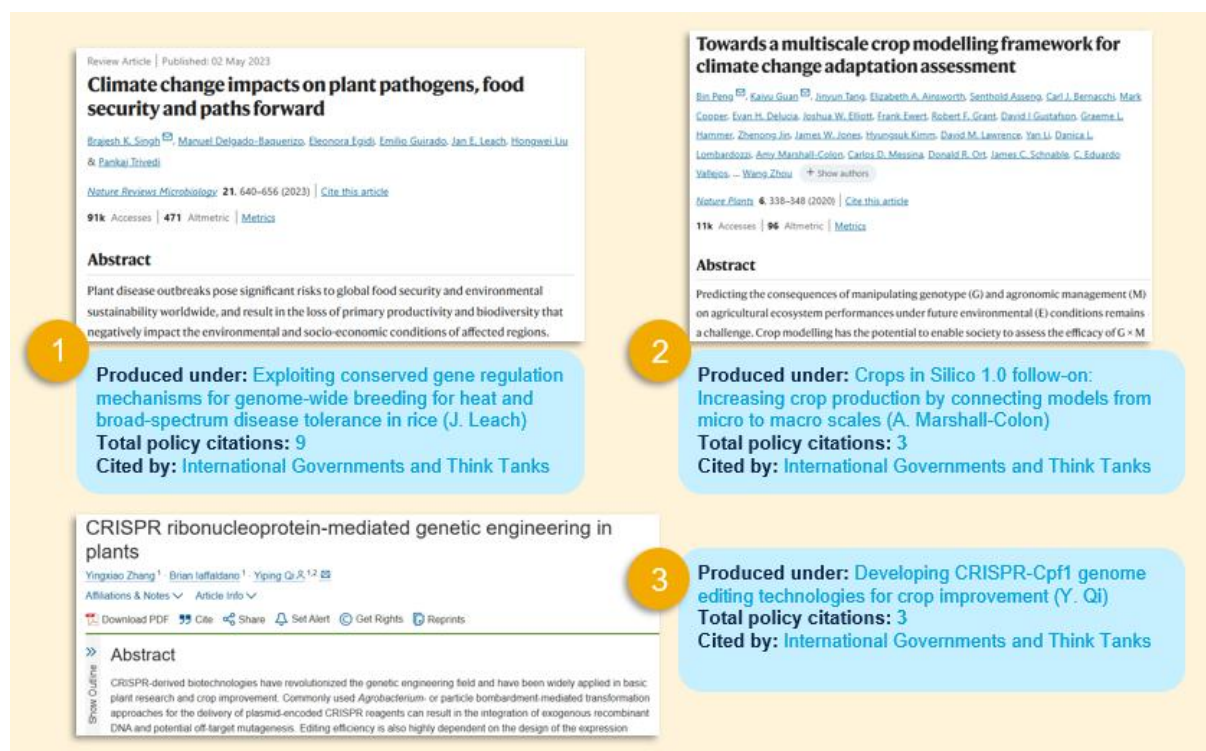


⁴ Described in more detail in the cross-comparison spreadsheet in Annex 1.

Next Generation Crops research was also cited by policy papers, as collected by [Overton](#). Of the publications reported by PIs in the final reports and surveys, Overton found 26 policy citations across 11 publications. Nearly all these policy citations were international, except for one policy paper by the Environmental Defense Fund. **Figure 6** shows the three most-cited publications by policy documents. The most prominently cited paper in the policy space was “Climate Change Impacts on Plant Pathogens, Food Security, and Paths Forward” (rice; PI: J. Leach), which has nine policy citations so far. The other two papers with the most policy citations were related to climate change or CRISPR technology.

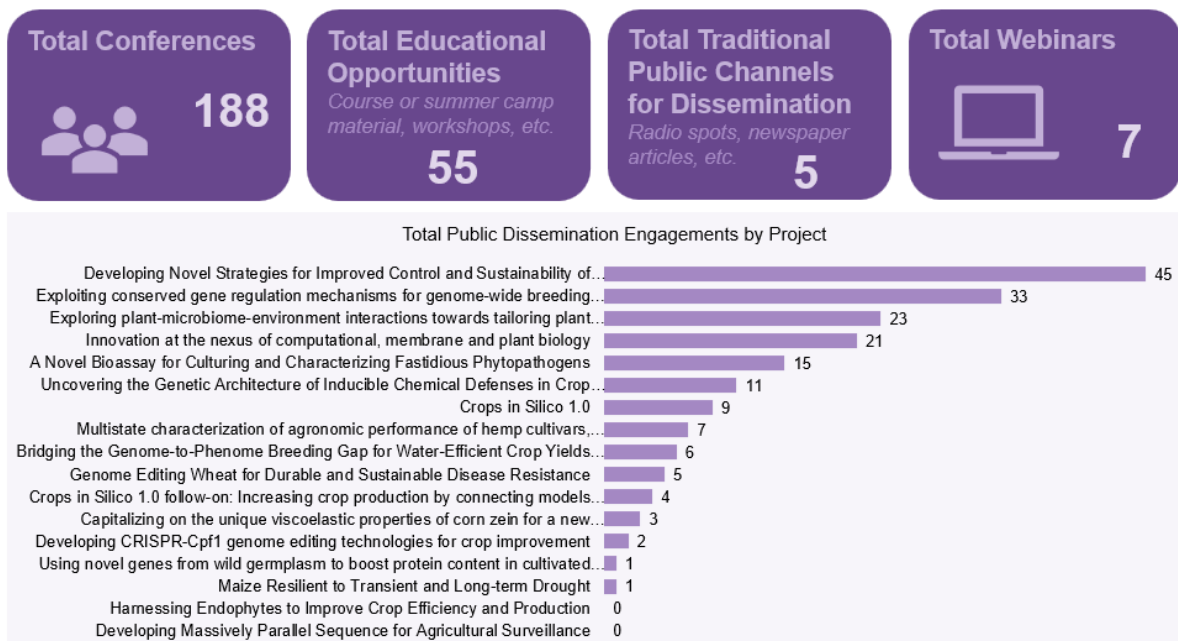


Figure 6. Top three most-cited publications in policy documents



In addition to public dissemination through the peer-reviewed literature, PIs disseminated their research via a variety of external public engagements, as shown in **Figure 7**. Conferences were by far the most popular mode of sharing research, with PIs or other key project team members attending 188 conferences to share their research. PIs also utilized other educational opportunities, traditional channels of dissemination, and webinars to present findings to other researchers as well as end users. The total numbers presented here are likely underestimated, because some PIs did not respond to the survey and provide more updated numbers, and some projects did not report any public dissemination engagements in the final report, though it is likely project team members did have public engagements as these types of events are extremely common and foundational to an academic’s professional career. RTI expects engagements were not tracked as carefully and reported as accurately as publications for projects.

Figure 7. Project public engagements by engagement type and project



Research Question #2: To what extent have Next Generation Crops innovations advanced toward commercialization (increasing the likelihood that they will ultimately be adopted by end users)?

As previously described, RTI worked with FFAR to adapt FFAR’s RDD framework to better reflect the goals of the Next Generation Crops portfolio (**Annex 5**). Then RTI used the web-based surveys and a thorough document review... to estimate the degree to which each project advanced according to the RDD framework. For projects that did not have a representative fill out the survey, RTI staff adapted by working to classify RDD stages based on data and evidence provided in the final report. Because these reports were often light on details, these numbers must be approached with caution.

Average results for RDD advancement are shown in **Figure 8**. The average starting point for innovations was Stage 2, meaning that at the time the project proposal was submitted, a solution hypothesis had been confirmed, but no lab testing had been done. Over the course of the projects, innovations advanced, on average, nearly three stages, to a Stage 4b (testing a prototype system) or a Stage 5 (using the actual technology in the operational environment). For the projects whose representatives responded to the PI survey about where the innovation stood as of April 2025, innovations had advanced to an average of Stage 6, which demonstrates that solutions were scalable, accessible, and compliant with regulatory requirements, which paves the way for adoption. These RDD advancements represent a significant accomplishment; Stage 6 was, for many innovations, the highest achievable stage, either because the innovations were research-oriented and not conducive to commercial adoption, or because the innovation’s incorporation into commercial technologies was too dispersed to track past this stage.

Figure 8. Average advancement in stages of RDD

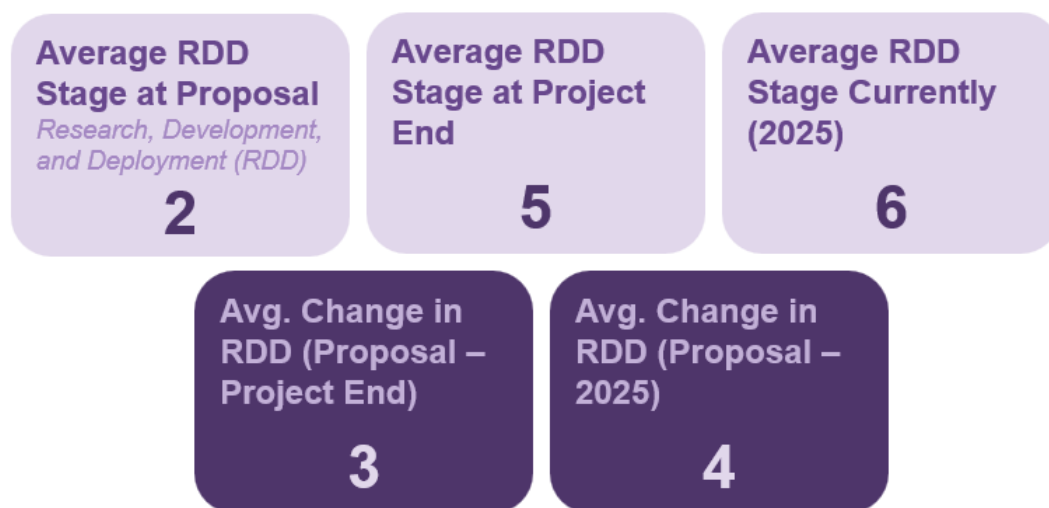


Figure 9 highlights the RDD advancement for the innovations from the evaluation’s two exemplars. Definitions and examples for each RDD stage can be found in **Annex 5**. Green indicates the stage at the time of the project proposal, blue shows the advancement achieved over the period of the project, and purple indicates the innovation’s advancement from the end of the project to the time of this report. The exemplars represent two of three projects with innovations that advanced to Stage 8, indicating the innovation has been adopted at a regional scale. RDD advancement for the remaining projects can be found in **Annex 7**.

Figure 9. Exemplar advancement in stages of RDD

Project Title (PI Name)	Innovation Description	Stage 1	Stage 2	Stage 3	Stage 4a	Stage 4b	Stage 5	Stage 6	Stage 7	Stage 8	Stage 9
Developing Novel Strategies for Improved Control and Sustainability of Grapevine Bunch Rot Management (M. Hu)	Grapevine late-season rots management for improved fruit and wine quality					Green	Blue	Blue	Blue	Purple	
	A disease risk model that minimizes unnecessary fungicide sprays for ripe rot disease on grapevines			Green	Blue	Blue	Blue	Blue	Blue	Purple	
Using novel genes from wild germplasm to boost protein content in cultivated chickpea (B. Riely)	First generation, high-protein chickpea varieties			Green	Blue	Blue	Purple	Purple	Purple	Purple	

■ Stage at time of proposal
 ■ Progression over period of project
 ■ Progression since project end to current

While advancements in RDDs were a highlight in this evaluation, patent advancement and approval evidence were less robust than other evaluation metric data. Six projects filed for a patent but, as of 2025, only one project had received one. This U.S. patent was for novel treatment and prevention methods used in (1) combatting the plant phytopathogen that causes citrus greening and potato zebra chip disease and (2) to ameliorate the effects of the

infestation. Two PIs took the initial step of applying for the general right to file in any country, but did not pursue that further by specifically choosing a country to file in within the standard deadline. Two other patents are still under examination, although one of the PIs, Dr. Yiping Qi, worked with an industry partner Syngenta that pursued its own patent filing—which has been granted—with a similar technology. The evaluation team could not find one patent in the patent databases searched; however, RTI was in contact with the PI, Dr. Brendan Riely, for one of the evaluation’s exemplar, who shared that this patent is not yet approved but highly likely to be approved given the ongoing commercialization of the innovation: a high-protein, early maturing chickpea seed aimed to penetrate the alternative proteins market.

While RDD advancement and patents were the main commercialization metrics used in this evaluation, there are several factors that can determine the degree to which a project is likely to commercialize. For example, RTI’s iCANVAS framework⁵ identified six facets of commercial readiness including technology readiness and regulatory status, development resources, inventors/team status, intellectual property, business strategy, and market fit. Some of these factors are addressed by RDD advancement and patents, but not all of them. A full understanding of the commercial readiness of these projects was outside of the scope of this evaluation.

Research Question #3: What is the potential that the Next Generation Crops-supported crops, if commercialized, will lead to increased farm profitability? If so, what will be the expected change in profitability?

The last research question was the most difficult to assess. Much of the funded research was upstream and/or was geared toward developing methodologies, tools, or other data products that were still a step or two away from being commercialized. Many of the projects were implemented by researchers that are not experts in commercialization and do not necessarily have commercialization goals. And sometimes the innovations, even if commercialized, were still a couple steps away from being adopted by farmers and providing on-farm benefits. Nonetheless, the evaluation team asked the PIs in the survey if data had been collected that would enable them to make an educated estimate for how much yield may increase or input usage may decrease because of the innovation(s) and to share that evidence. Therefore, while estimates were self-reported and uncertain, the question structure prompted responses that were data-driven.

Once RTI had this data, the evaluation team then took the extra step of calculating the monetary benefits provided by each innovation if they were implemented today (**Table 4**).⁶

⁵ For more on iCANVAS, see Pandiyan, M., (2021), *Beyond Technical Milestones: Incorporating Desirability into Your Medical Innovations*, https://nhlbicatalyze.org/files/events/CATALYZE_Beyond_Technical_Milestones_Incorporating_Desirability.pdf

⁶ For productivity, the 5-year average (2020–2024) for both the Marketing Year Average price and yield to determine the average revenue per acre for a given crop (using data from the United States Department of Agriculture [USDA] National Agricultural Statistics Service). This was then multiplied by the percent change in PI-estimated yield to get an estimated increase in revenue. The decrease in cost associated with reduced input usage for one project (grapes) was based on the PI estimate. The other project (corn) required pulling data from USDA Agricultural Marketing Service, Iowa Nutrient Research & Education Council, and the Corn Nitrogen Rate Calculator (developed in association with seven Midwestern universities).

These per-acre dollar values should not be construed as current or realized increases in revenue or decreases in cost; rather they represent the current dollar value that *would be realized if* these innovations were implemented by end users *today*. In reality, these benefits would likely be realized years into the future and those would need to be heavily discounted to the present. Nonetheless, these numbers do help to provide a sense of scale in monetary terms. This report does not provide per acre dollar values for the grapevine ripe rot and chickpea case studies as they were monetized in greater detail in the separate case studies, summarized in **Table 5** below. These case studies reflect “exemplars” of research projects with high potential for downstream benefits and reflect realistic projections of the value those projects may provide to farmers based on current evidence. The high level of benefits is impressive considering the modest cost that FFAR initially invested.

Table 4. Estimates of innovation value by crop

Crop	Project	Per Acre Dollar Value	Revenue ↑ - or - Cost ↓
Sorghum	Bridging the Genome-to-Phenome Breeding Gap for Water-Efficient Crop Yields (G2P Bridge)	\$62- \$94	Revenue ↑
Soybeans	Increasing crop production by connecting models from micro to macro scales (Crops in Silico 1.0 follow-on)	\$49 - \$62	Revenue ↑
Corn	Increasing crop production by connecting models from micro to macro scales (Crops in Silico 1.0 follow-on)	\$73 - \$91	Revenue ↑
Corn	Maize Resilient to Transient and Long-term Drought	<u>Up to \$274</u>	Revenue ↑
Corn	Maize Resilient to Transient and Long-term Drought	\$18	Cost ↓
Grapes	Developing Novel Strategies for Improved Control and Sustainability of Grapevine Bunch Rot Management	\$450	Cost ↓

Based on self-reported technical outcome projection in current dollars.

Table 5. Exemplars’ modeled cost-benefit analysis results (US\$ thousands)

Project Title (PI Name)	Type of Benefit Accrued to Farmers (Years Modeled)	Real, Discounted Benefits	Real, Discounted Costs	Net Present Value of Benefits
Using Novel Genes from Wild Germplasm to Boost Protein Content in Cultivated Chickpea (B. Riely)	Prospective (2025–2035)	\$56,710	\$1,157	\$55,552
Developing Novel Strategies for Improved Control and Sustainability of Grapevine Bunch Rot Management (M. Hu)	Realized (2020–2024)	\$7,492	\$407	\$7,085
	Prospective (2025–2035)	\$37,598	\$407	\$37,191

Implications for Future Summative Evaluations

Through desktop reviews, research, and surveys, this evaluation was able to collect, standardize, and summarize a substantial amount of data and information about the achievements of the completed Next Generation Crops projects. However, several factors limited a full accounting of the outcomes, including the fact that some projects ended years ago (i.e., the longer since the project, the more difficult recall becomes for PIs, some PIs had often moved on to different organizations, and/or had unknown updated contact information) and final reporting lacked the ability to draw out key and nuanced details. Throughout this summative evaluation, RTI noted a few areas where FFAR could make changes to increase the chances of having a more comprehensive accounting of project outcomes:

- **At the RFP stage:** Provide explicit guidance about teams' monitoring and learning strategies, and direct teams toward the minimum threshold of information that teams are expected to collect. Additionally, if FFAR is interested in understanding project impact on research, commercialization, and farm profitability, request that offerors use the appropriate metrics and to state and budget explicitly for how they plan to collect this information.
- **During project implementation and reporting:** For annual and final reporting, provide more explicit guidance about the details that FFAR would like project teams to report on and substantiation of those details.
 - For publications, request that PIs provide the DOI numbers of manuscripts to which the project contributed to enable and streamline bibliometric evaluation.
 - For patents, request that PIs provide a link to the patent application and status to facilitate tracking patent progress after the project ends. Consider asking PIs to point toward evidence of adoption by next or end users (along with specific names and contact information if available) and to rank the degree to which projects made advancements in the stages for RDD.
 - Lastly, for public dissemination engagements, provide specific guidance on what constitutes these types of engagements and how to track participation. There may be other instances where more specific question language could benefit the goals of post-project evaluation.
- **At the end of the project:** After a project submits their final report, hold an end-of-project meeting or "exit interview" to better understand the details of the project and any responses to the final report that may have been unclear or require additional information. Ask about factors that are critical in determining the future success of the research and challenges or recommendations for FFAR to foster a more successful project. Clarify with PIs or their team members their interest and ability in providing input into future evaluations.

Conclusion

This evaluation highlighted standout and summary accomplishments from the Next Generation Crops portfolio. The portfolio has performed well, effectively advancing research

across a diversified number of crops, generating a wealth of research outputs, and supporting promising different types of innovations that have the potential to increase benefits to farmers. FFAR's investments also led to significant amounts of additional funding, and enabled projects to advance in RDD levels.

The wide diversity in both crops and types of innovation supported by the Next Generation Crops portfolio implies a tradeoff between a wider set of outcomes versus a narrower set of breakthroughs. Also, the upstream and research foci of the investments meant that projects were generally more geared to producing innovations that served as public goods that could underpin future commercialization, rather than being optimized for commercialization as an end goal. Despite the requirement for match partners, researchers were not always successful at working with them to apply for and obtain patents that could later be commercialized.

Investing in unproven innovations is inherently risky, and the two exemplars showed that outsized impacts could be achieved by taking advantage of opportunities in two disparate agricultural industries (East Coast wine grapes and high-protein chickpeas). In addition to showcasing the impressive impacts of these projects, FFAR can learn from and build on these successes to replicate them in the future.