Accomplishments, Deliverables and Impacts.

The best measure of NRSP-4's (aka IR-4's) accomplishments and deliverables is through tracking establishment of pesticide tolerances and/or registrations by the United States Environmental Protection Agency (EPA) that were supported by NRSP-4 submissions of data/information for crop protection products (chemical and/or bio-based pesticides) for use on specialty crops and specialty uses in major crops. The research work that leads to these approvals is also a key indicator of productivity.

The information in this document is a summary of NRSP-4's accomplishments from 2016 to 2019/2020. Additional details, including the listing of the specific specialty crops/specialty uses and crop protection products supported can be found in IR-4 Annual Reports, see https://www.ir4project.org/about-ir4/outreach-2/

NRSP-4's "deliverables", the registrations of pest management products for specialty crops and specialty uses in major crops, solves some very real problems farmers/growers face. Individual farmers/growers and commodity associations continue to articulate testimonies on how IR-4 helps them feed Americans and beautify the environment. To better ascertain the impact of IR-4's research and regulatory activities, Drs. Steve Miller and John Mann of Michigan State University's Center of Economic Analysis authored a report of the economic impact of IR-4 Project's activities in the Food, Ornamental Horticulture and Biopesticide and Organic Support programs (http://ir4.rutgers.edu/Other/IR4%202017%20Impact%20Final.pdf). According to the report, "the estimated total effects of the IR-4 Project includes supporting an estimated 95,261 jobs with total labor income of $5.6 billion and annual contributions to gross domestic product totaling about $9.4 billion. These impacts represent best estimates of ongoing contributions to the U.S. economy, largely through crop agricultural productivity and damage mitigation via pest management."

IR-4 focuses its research on modern lower/reduced risk chemical pesticides and biopesticides. The strategic decision to focus on these newer products has helped growers can produce their commodities with the best available technology to manage pests with the highest degree of safety for humans and the environment. Many of the registrations are for products that are important to Integrated Pest Management systems.

Food Program-Residue Studies

IR-4 develops its annual work plan based on decisions and directions of stakeholders at annual IR-4 priority setting workshops. IR-4 establishes research studies to address the highest priority crop protection voids also known as a PR or Request for Assistance. The research involves EPA Guideline Magnitude of the Residue Studies performed at various IR-4 Field Research Centers that are associated with research farms at Land Grant Universities, Agriculture Research Service or Agriculture Canada sites. The number of residue studies and associated field trials conducted by year are as follows:

	2016	2017	2018	2019	2020 (est.)	Average
Residue Studies	76	76	68	71	71	72
Field Trials	439	468	380	406	446	427

At each IR-4 Field Research Center site, the lead scientist, or IR-4 Field Research Director, will apply the test pesticide to the crop according to rates, timings and other details outlined in the detailed research protocol. When the crop is mature, representative samples are harvested, frozen, shipped to the analytical laboratory. The dedicated IR-4 analytical laboratories utilize modern residue chemistry methodology to determine the amount of pesticide residues remaining in/on the crop. All data are sent to the Study Director, who critically reviews the data, assesses fitness of results, drafts the report in EPA accepted format, collects supporting submission documents for cooperating registrants and then submits the data to EPA. The number of residue study submissions by Active Ingredient and the number of Request for Assistance addressed are as follows:

Submissions	2016	2017	2018	2019 (est.)	Average
Active Ingredients	30	28	23	23	26
Requests for Assistance covered	107	194	160	154	153

Once received by EPA, their scientists perform a detailed risk assessment to determine the dietary risk from the additional uses on specialty crops/specialty uses on major crops. EPA also performs ecological risk and several other assessments to determine if the proposed IR-4 uses pose unacceptable risk to workers, the water, pollinators, non-target crops and other aspects. Only the uses that meet EPA threshold for acceptable risk are approved via established pesticide tolerances that are published in the ***Federal Register***.

When proposing new pesticide tolerances, IR-4 often utilized Crop Groups or other data extrapolation models to ensure that the pesticide tolerances extend to as many crops as appropriate. IR-4 and EPA continue to partner in the development and/or expansion of Crop Groups which formally allow residue data developed on a few representative crops to be extended on many similar crops. For example, residue data developed on lettuce, mustard greens and spinach allow pesticides tolerance on over 50 leafy vegetables. EPA will also considers case by case extrapolations to extend the pesticide tolerances.

The number of approved tolerances/associated uses are as follows:

Approvals	2016	2017	2018	2019 (est.)	Average
Tolerance	157	65	208	210	160
Uses	1000	534	918	1560	995

Please note the accomplishments in 2019 in the traditional Food Program is the highest level recorded in one year during the 56 years of IR-4's existence.

Food Program-Product Performance

The need for IR-4 to develop product performance data (efficacy and crop safety research) to support labeling of new uses for specialty crop pest management is an important priority in the IR-4 Project's annual research plan. In many cases, these data are important to have prior products being made available to growers. Efficacy and crop data are also required to be included in the registration package for state registration in California sometimes in other states. During the period of the current NRSP-4 project, IR-4 performed the following product performance activities:

Performance	2016	2017	2018	2019	2020 (est.)	Average
Projects	43	52	46	69	TBD	53
Field Trials	89	104	89	117	TBD	100

Food Program-Integrated Solutions

In order to better service the needs of the IR-4 stakeholders, IR-4 implemented the Integrated Solutions Research Program in 2018. Integrated Solutions is a hybrid of an existing Food Program, "Pest Problems without Solutions (PPWS)" research and elements of the traditional Biopesticide research program. The goal is to bring more biopesticide products into conventional agricultural systems, giving farmers more good options to

manage hard to control pests, ensure residues in the fruits/vegetables/nuts scheduled for export are within established limits or manage pest resistance to pesticides.

The first research trials were implemented in 2019. IR-4 funded projects for wireworm on potato, Bacterial diseases on onion, Verticillium wilt on eggplant, damping off on hemp, cucumber beetle/corn rootworm on watermelon and annual weeds in tomato. The first year was a success and many of the projects will continue and several new ones will be added to the 2020 research program.

Food Program-Crop Groups

IR-4 continues to submit proposals to EPA to expand and enhance extrapolation models that improve efficiency of the tolerance setting process by having data on a small number of crops be extended to other similar crops. The extrapolation models include crop groups and crop sub-groups. The proposed revised Non-grass Animal Feeds (Forage, Fodder, Straw and Hay) Crop Group 18 was submitted to EPA in 2016. The final rule for Leafy Vegetables (except Brassica) and Brassica Vegetables and the new crop groups for Stalk, Stem, and Leaf Petiole; Tropical and Sub-tropical fruit, edible peel and Tropical and Sub-tropical fruit inedible peel was published on May 3, 2016. The CHEMSAC committee in EPA has reviewed and approved the revised Root and Tuber, Leaves of Root and Tuber Vegetable and Legume Vegetables and Foliage of Legume Vegetable groups. EPA published the proposed rule modifying the Herb and Spice Group in 2019. This proposal separates the old crop group into two new crop groups, “Crop Group 25, Herb Group” and “Crop Group 26, Spice Group”. This will promote greater use of these groups for tolerance setting purposes, both domestically and in countries that export food to the US.

The crop group effort also continues with the Codex Committee of Pesticide Residues. Fruit, Vegetable, Grass, Nuts, Seeds and Saps and Herb and Spice Codex types have all been completed. Animal Feeds and Processed Foods will be considered at the CCPR meeting in April, 2020.

Food Program-International

IR-4 remains committed to assisting US specialty crop growers in expanding their markets by exporting fruits and vegetables to international trading partners through harmonizing pesticide residues standards in specialty crops. Currently, in many cases pesticide residues can be a technical phytosanitary trade barrier.

In North America, IR-4 has an excellent partnership with Agriculture and Ag-Food Canada’s Pest Management Centre (CN-PMC). A significant and increasing amount of IR-4 work is performed in cooperation with Canada. Below is an outline of the CN-PMC research contributions to the IR-4 program.

Ag Canada involvement in IR-4 research	2016	2017	2018	2019	2020 (est.)	Average
Field Trials	33	32	22	29	31	29
Studies Managed	4	3	4	5	TBD	4

IR-4 believes that the research benefit of working on joint residue studies with CN-PMC saves IR-4 an estimated $500,000 per year. In addition, the CN-PMC program continues to provide significant contributions to IR-4 efficacy and crop safety research, and shares ornamental efficacy and crop safety data with IR-4. There

also continues to be a good exchange of personnel with CN-PMC participating in various IR-4 meetings and vice versa.

IR-4 also works with other countries. Research priorities identified in the first and second Global Minor Use Workshops continue to make progress, and a number of studies are under consideration for fruit fly control in tropical crops, such as use of the pesticide spinetoram in Latin America. Many of the secondary priorities are also being considered including the registration of flonicamid in the US, Canada and Mexico to address aphid control in legume crops. Anthracnose on tropical crops was raised as a priority, and IR-4 is undertaking a number of residue studies along with Costa Rica and Peru to address this need.

Many of the studies under the Global Capacity Development, Residue Data Generation Project were completed in 2016 and 2017. These studies were subsequently reviewed by the Codex Committee of Pesticide Residue with nearly every project resulting in the adoption of MRLs. Coordinated by USDA-Foreign Agriculture Service (USDA-FAS), this project's objective was to enhance the capacity of participating nations in Asia, Africa and Latin America to meet pesticide-related requirements based on international (Codex) standards. These collaborative residue data generation projects on low risk products (e.g., pyriproxyfen and spinetoram on tropical fruits) incorporated all technical aspects of these studies and provided expertise in national residue monitoring. The focus of IR-4's contributions has been to develop the expertise needed to conduct field and laboratory pesticide residue studies under Good Laboratory Practices and to eventually provide data to local authorities and Codex to support product registration. All three of the regions participating in this project have received Standards Trade Development Facility (STDF) and USDA-FAS funding, which provides support for IR-4's contributions to the project.

At the request of EPA, IR-4 personnel continue to be included as part of the U.S. delegations to the: Codex Committee on Pesticide Residues; the Organization for Economic Co-operation and Development (OECD), Expert Group on Minor Uses, the Working Group on Pesticides and the Expert Group on Biopesticides; and the North American Technical Working Group on Pesticides. IR-4 plays a key role in these activities by supporting global standards and incentives that support specialty crops. These include global recognition of crop grouping and extrapolation as well as promoting harmonization of pesticide tolerances on specialty commodities. IR-4 also assists other countries, both developed and developing, as they begin to establish minor use programs. The knowledge and expertise of IR-4 is often sought after and is highly valuable to these countries as their minor use programs evolve.

Food Program-Impacts

As noted above, Drs. S. Miller and J. Mann of Michigan State University's Center for Economic Analysis has performed an assessment of the impact of IR-4 Project contributions to the gross domestic product. In their report they placed a monetary value on the contributions of the various IR-4 research objectives. According to the Michigan State University report, ***"The Food Crops Program estimated economic impacts measure the direct change in the productivity and all associated secondary impacts. To be sure, impacts are estimated based on the value of specialty food crop production and on pesticide use made available by the IR-4 Project, where specialty food crops is used as a proxy of the value of minor use crop production. Accordingly, specialty crop productivity enhancements afforded by IR-4 Project registrations of $4.78 billion is expected to support 35,028 agricultural jobs and contribute to about $4.0 billion to annual gross domestic product. Once accounting for secondary transactions, food crop productivity enhancements created 70,868 domestic jobs with $4.2 billion annual contributions to labor income and $7.1 billion contributions to gross domestic product"***

Environmental (Ornamental) Horticultural-Core Research

IR-4 continues to conduct environmental horticulture research trials to support registrations in the greenhouse, nursery, landscape, Christmas tree and forestry industries. The IR-4 trials consist of two types of research. First, efficacy trials are designed to compare different products to manage damaging insects, plant diseases and weeds and to measure the impact of growth regulators. Secondly, Crop Safety is determined including the level of phytotoxicity to crops when using herbicides to manage common weeds in and around nurseries. Please see below for a summary of research activities.

Environmental Horticulture Research	2016	2017	2018	2019	2020 (est.)	Average
Efficacy Trials	255	253	220	200	TBD	243
Crop Safety Trials	507	490	408	471	TBD	475
Total Trials	782	743	628	671	TBD	699

Environmental (Ornamental) Horticultural-Submissions & Successes

Reports from field trials are utilized to develop data summaries that are submitted to the cooperating regulatory companies. The companies utilize the data to add restrictions to registrations when something is deemed too phytotoxic or add a new pest when data indicate that the product is effective. Below are numbers of submissions and successes.

	2016	2017	2018	2019 (year to date)	2020 (est.)
Submissions	20	21	21	17	20
Federal Registrations	1	1	5	3	3

Environmental (Ornamental) Horticultural-Impacts

Michigan State University Center for Economic Analysis estimated the economic impacts of the Ornamental Horticulture Program. The authors reported ***"Given the relatively small size of this segment, a priori expectations suggest the impacts will be smaller than for food crops. Accordingly, about 3,053 individuals are employed in ornamental and horticulture industries because of the productivity effects afforded by the Ornamental Horticulture Program. These generate about $200.6 million in labor income and contribute about $289.1 million to annual gross domestic product. Once accounting for indirect and induced effects, the Ornamental Horticulture Program generates about 6,470 jobs, with labor income totaling $385.6 million. It also expands annual gross domestic product by just about $597.2 million."***

Environmental (Ornamental) Horticultural-Pollinator Protection Research

Activities aimed at protecting pollinators are a high priority for the agricultural community and the public and is affecting decision making at many levels, from individual consumers to the federal government representatives. IR-4 is leading a USDA-NIFA funded Specialty Crop Research Initiative (SCRI) research project is expected to provide crucial, science-based information for grower decision making and provide opportunities for the Environmental Horticulture industry to contribute to improved pollinator health by growing plants under best production practices, thereby increasing pollinator forage quality and quantity in rural and urban landscapes. The research project team is comprised of entomologists and agricultural economist from Clemson University,

Connecticut Agriculture Experiment Station, Cornell University, Michigan State University, Penn State University, University of California, University of Florida and University of Kentucky.

IR-4 in cooperation with several universities established test garden plots of common annuals and perennials and then collected/counted the number of visiting pollinators. The research team began studies on the amount of systemic insecticides found in pollen and nectar of rhododendron, snapdragon, annual salvia, perennial salvia, dahlia, and kniphofia. Additionally, the team has started compiling the available efficacy and toxicology information for alternative treatment options and have developed a grower survey to understand the economic and social impacts related to neonicotinoid use or lack thereof. The team has also developed the consumer online and eye tracking survey tools to assess consumer willingness to pay and preferences related to grower production practices. The team has published three scientific articles, has another accepted and one in revision, has written 17 trade articles, and has given more than 20 scientific and 47 trade presentations.

Biopesticide and Organic Support-Successes

IR-4 submitted an amended registration package for ***Aspergillus flavus*** AF36, Prevail, for use on commercial almond and fig orchards. EPA has granted an exemption from the tolerance for residues of the pesticide ***Aspergillus flavus*** AF36 in or on dried figs.

An Experimental Use Permit was obtained for the state of Texas using ***Aspergillus flavus*** TC16F, TC35C, TC38B, TC46G on corn. IR-4 submitted a petition to EPA requesting temporary tolerance exemptions for the product FourSure, which will expire on June 30, 2020. Researching the displacement of aflatoxin producing fungi by ***Aspergillus flavus*** has been long supported by the IR-4 Project. Beginning in 1997, a grant funded project was led by Peter Cotty of USDA-ARS. This resulted in registration on cotton in 2004. Themis Michailides and the Arizona Cotton Research & Protection Council contributed to the registration of Aspergillus flavus AF36 on pistachio. An Experimental Use Permit was achieved in 2013 for use on commercial almond orchards and a Section 3 has been submitted.

The US EPA also approved the product LifeGard by Certis USA in 2016. The project focused on the development of a biological control product based on ***Bacillus mycoides*** isolate J (BmJ), and has been the subject of efficacy work by the IR-4 Project for several years. BmJ strain PTA-4838 is currently exempt from the requirement of a tolerance.

Potassium salts of hop beta acids is a new active ingredient for the management of Varroa mite in honeybee hives. In 2016, the registration package IR-4 submitted resulted in 3 products registered including the technical grade active ingredient, the manufacturing use product and the end use product which has the trade name HopGuard II. The HopGuard II also represents a change in the manufacturing process compared with HopGuard. A revised label was submitted for HopGuard II in 2016. HopGuard II was effective in managing varroa mites during 2015 and 2016 trials funded by the IR-4 Project.

Also in 2016, a residue study on Anthraquinone in rice occurred thanks to the combined efforts of the Food Use and Biopesticide and Organic Support Programs. Data were submitted to the registrant, and Anthraquinone was registered on rice as a bird repellent. Previous efficacy work was funded by the Biopesticide and Organic Support Program in 2007 and 2010, in rice and blueberries, respectively.

The EPA approved the bioinsecticide PFR-97 label amendment request to add management of flies in mushroom houses. Other amendments include the addition of basil, cabbage, potato, and apple to the Stargus (***Bacillus amyloliquefaciens*** F727) label. Regulatory support focused on control of ***Phytophthora infestans*** and ***Erythroseptica*** in potato with the biofungicide previously known as MBI-110. These label changes were also supported by efficacy trials funded by the Biopesticide program.

In 2018 IR-4 completed registration of 2 new active ingredients which were based on registration packages to EPA for PMV-01 for the management of Pepino Mosaic Virus in tomato and for ***Metschnikowia fructicola*** for the management of diseases in the Small fruit vine climbing subgroup, except fuzzy kiwifruit (Crop Group 13-07F). IR-4 also submitted a number of additional studies to the EPA to support the pending request for *Pseudomonas fluorescens* ACK55. In addition, a new use and tolerance was established for 6BA on avocado.

The EPA approved a label amendment request to add a supplemental label for Delegate WG (Spinetoram) to reduce the PHI on bushberries (Subgroup 13-07B), except lingonberry. This label change was supported by efficacy trials funded by the Biopesticide program

Biopesticide and Organic Support-Impacts

Michigan State University Center for Economic Analysis reported ***"biopesticides make up a small but growing segment of the agro-pest management market. We estimated that crop productivity impacts of IR-4 Project supported biopesticides generates about $1.2 billion in added crop sales. This supports about 5,306 agricultural jobs with total annual income of $343.5 million. Once accounting for all secondary transactions, the expected macroeconomic effects add 17,340 jobs with labor income of $962.8 million and annual contributions of $1,627.9 million to gross domestic product."***