Pest management solutions for specialty crops and specialty uses

2021

Annual

Report

The IR-4 Project

ANNUAL REPORT OF THE IR-4 PROJECT[1]
January 1, 2021 - December 31, 2021

Summary of Accomplishments

- Successes
  - EPA publication of 14 actions that established 115 new tolerances for 13 active ingredients. These tolerances support 640 potential new uses on food crops
  - One new registration was approved by EPA and one amended registration was approved by a state to expand the registrations and impact 1511 Environmental Horticulture crops
- Regulatory Actions
  - Food Program - IR-4 submitted to EPA 20 tolerance petitions that covered 103 unique requests for assistance and crop group tolerance updates (PR #s)
  - Environmental Horticulture Program - 20 submissions of data reports to companies to support new or update existing registrations
- Research
  - Food Program
    - 48 new Magnitude of the Residue Studies, and a total of 341 residue trials
    - 79 efficacy/crop safety trials that contributed to 37 Product Performance projects
    - 41 field trials that contributed to 21 Integrated Solutions projects
  - Environmental Horticulture Program
    - 598 field and greenhouse trials (233 efficacy, 365 crop safety) that contributed to 54 projects
- Other
  - Completed the move of IR-4 Headquarters from New Jersey to its new home at NC State University in Raleigh
    - Hired 14 people, team members at IR-4 Headquarters; started training for many who were not previously connected to IR-4 or are new to their position
    - Established new offices on campus
    - Moved nearly 60 years of paper files from their previous home
    - Moved IR-4 databases and other IT components to new home on NC State servers
    - Completed the shutdown of the Rutgers offices on time and under budget
  - Converted IR-4 funding process to a single grant to run the national operations of IR-4; previously the funds were split from HQ and the Regions
  - Reworking of IR-4's communications/outreach including updated/enhanced website, and more active presence on various social media platforms

Food Use Program

Within the Food Use Program, IR-4 has six sub-objectives:

1. **Magnitude of the Residue Studies**: Following EPA guidelines, these studies provide data to set regulatory standards (pesticide tolerances or Maximum Residue Levels-MRLs) for the amount of chemical pesticide and /or its metabolites remaining on a crop at harvest or in a processed commodity (e.g. juice).
2. **Product Performance Testing**: Development of crop safety and/or efficacy data that provides assurances that the use of a pesticide (chemical or bio-based) is safe and effective.
3. **Crop Extrapolation Models**: Development of new proposals to expand and enhance the formal codified EPA Crop Groups/Sub-Groups, IR-4 crop grouping efforts propose models that allow collection of residue data on a small number of representative crops. That data then supports pesticide tolerances for a much larger

[1] IR-4 Project, or Inter-Regional Research Project Number Four, is authorized by the Directors of the State Agricultural Experiment Station Directors as National Research Support Program Number Four (NRSP-4)

number of similar crops in the crop group or subgroup. Crop grouping extrapolation allows IR-4, the regulated community and EPA to use resources in a smart and efficient manner.

4. **Integrated Solutions**: Research utilizing all available crop protection tools in order to develop specific solutions for hard to manage pests, prevent or better manage pest resistance (to pesticides) and mitigate pesticide residues in the final food product. Integrated Solutions research also addresses management of pests in organic crop production systems.
5. **Biopesticides**: The continued goal of the IR-4 Biopesticide and Organic Support Program is facilitation of registration of crop protection products classified by EPA as Biopesticides. The program provides registration assistance to university and USDA researchers as well as to small biopesticide companies, with regulatory advice and petition preparation assistance.
6. **International Program:** Through various means IR-4 has developed, IR-4 assists domestic specialty crop growers' ability to export fruits, vegetables and other specialty crops to international markets by harmonizing pesticide residue standards. Partnerships developed by IR-4 enable harmonization of pesticide residue standards (Maximum Residue Levels) and avoiding non-tariff trade barriers. Two new partners in the IR-4international efforts include the Minor Use Foundation and CERSA.

Research Activities – Food Residue/Product Performance/Integrated Solutions

Since 1963, IR-4 stakeholders have submitted 13,391 requests for assistance to the IR-4 Food Use Program. Of these, 319 are currently considered "researchable projects" that remain as outstanding documented needs of specialty crop growers. The other requests have been addressed through previous research and regulatory submissions or cannot be registered at this time. The total number of new requests added to the IR-4 tracking system during 2021 was 197, including 51 requests to track new crop group updates, international requests or other miscellaneous factors.

IR-4's research priorities for 2021 were determined by stakeholders during the September 2020 IR-4 Food Use Workshop, held virtually, on-line. Based on the outcome of that workshop and other priority-setting mechanisms[2], IR-4 scheduled 48 new residue studies in 2021.

In support of the **residue studies** in 2021, there were a total of 341 field trials. This total included 291 IR-4 "State" field trials conducted by land-grant university scientists, 40 field trials conducted by ARS researchers and 10 field trials managed by IR-4's partners in the Canadian Pest Management Centre (CN-PMC). These numbers include 28 carryover trials from trials lost in 2020 due to weather or other issues. The new studies for 2021, including test chemical and crop, are shown in Attachment 2.

Most residue samples developed in the field trials are assigned to the IR-4 Analytical Laboratories. When necessary, other cooperating facilities or contractors may be utilized to ensure projects are completed in a timely manner.

IR-4 also addressed the **efficacy and/or crop safety data** needs for 37 projects by establishing 79 field trials. See Attachment 3 "2021 Food Use Product Performance Research Program" for full details. In addition, IR-4 continues to work closely with registrants and researchers to understand the quantity and scope of data requirements, and to ascertain the status of research results.

The 2021 **Integrated Solutions** research focused on 21 main project areas shown below. Out of the 21 projects, 7 projects were carry-overs from the previous year(s), and 14 were new projects that were prioritized by stakeholders in 2020 (includes 3 projects that were supported by CDA).

Integrated Solutions #	Title
2020 Carry-over projects:	
IS00372	Corn earworm larvae / Sweet corn

[2] IR-4 reserves a handful of priorities to address written proposals to "upgrade" projects and other projects to answer regional needs,

IS00381	Cabbage maggot / Root and tuber crops
IS00357	Lepidoptera / Hemp
IS00330	Orobanche parasitic weeds / Processing tomato
IS00348	Bacterial diseases / Post harvest organic sweet potato
IS00368	Fire blight (*Erwinia amylovora*) / Apple, Pear
IS00380	Bitter rot (*Colletotrichum* spp.) / Apple
2021 New projects:	
IS00166	Cabbage maggot / Brassica leafy greens crops
IS00382	Mites / Hemp
IS00397	Thrips / Green onion
IS00376	Grape leafhopper / Grape
IS00002	Glyphosate resistant weeds / All crops
IS00383	Post-emergence broadcast control of escaped weeds / Sweet potato
IS00390	Weed control / Cold-hardy small fruits
IS00389	Dormancy break / Grape
IS00393	Weeds / Date palm
IS00344	Powdery and downy mildew / Organic cucurbits
IS00384	Anthracnose (*Colletotrichum* spp.) / Coffee
IS00391	Damping off / Organic hemp (GH)
IS00388	Nematode, sting (all species) / Strawberry
IS00399	Rust / Coffee

For protocols and reports please see: https://ir4app.cals.ncsu.edu/Ir4FoodPub/IS_trial.

Submissions and Successes - Food Use Residue

IR-4 submitted data to EPA or to cooperating registrants for 20 chemicals, addressing 103 specific IR-4 requests (PR#s) for assistance. See Attachment 4 for a comprehensive listing of submissions made in 2021.

Based on IR-4 data and/or submissions, in 14 regulatory actions EPA reviewed 13 chemistries in 2021 and established 115 tolerances which can support 640 new uses. The 640 new uses in 2021 bring the IR-4 58-year total of clearances to 22,572. A complete list of the new 640 uses is in Attachment 5.

Compliance with EPA Good Laboratory Practice Regulations

The Annual IR-4 QA Planning Meeting was held virtually on February 24, 2021, March 1, 2021 and March 3, 2021. At this meeting, the audit plan for IR-4 QA officers for the 2021 field trial season was created. For calendar year 2021, regular inspections included 16 facilities, 165 in-life audits of field trials, 85 in-life audits of residue analytical laboratory activities, 36 analytical summary report/data audits and 403 field data book audits. During the 2021 calendar year, 45 final reports and amended reports were audited.

IR-4 facilities continue to work hard to meet the high standards demanded under GLP requirements. IR-4 has participated in a total of 184 EPA GLP IR-4 facility inspections since April 27, 1997, with only periodic minor findings to-date. In 2021, the EPA performed one remote virtual compliance monitoring for GLP compliance/data integrity at an IR-4 research site.

IR-4 continues to use the eQA (electronic) reporting system to improve efficiencies and enhance communications across the program. Over 883 inspection and audit reports were processed using the web-based system in 2021. The electronic system was expanded in 2017 to include a document management system (eDOCs). This document management system is used to post protocols/changes, analytical methods and certificates of analysis for GLP test

materials. To-date some 4605 sortable documents have been placed in the eDOCs system and are readily available to IR-4 study participants. In 2020, the document management system was further expanded to include HQ SOPs. Training of HQ SOPs has been enabled with the eDOCs system.

Crop Grouping Initiative

The IR-4 Food Crops Program continuously strives to work smarter and more efficiently to deliver new crop protection products for specialty crop growers. The 20 submissions in 2021 support hundreds of new uses based on established crop group extrapolations. Often IR-4 realizes as many as 10 or more new uses for each residue study submitted. Phase V in the series of planned crop group amendments included the final rule to modify crop group 19, Herb and Spice Group which created two new crop groups and was published on November 6, 2020. The proposed rule for Phase VI is expected to be published in early 2022 and will include revisions to crop groups Crop Group 6: Legume Vegetables; Crop Group 7: Foliage of Legume Vegetables; Crop Group 15: Cereal Grains; and Crop Group 16: Forage, Fodder and Straw of Cereal Grains.

International Activities

In North America, IR-4's cooperation with Canada's Pest Management Centre continues to be mutually beneficial when priorities align. Canada contributed a smaller number of field trials than usual to the joint residue program in 2021, due to impacts of the global pandemic.

The IR-4 Project, in conjunction with the Minor Use Foundation, developed new projects in Latin America, Africa and Asia stemming from the Global Minor Use Priority Setting Workshop. which was held in September, following the Food Use Workshop. Additional efforts are underway to determine the best solutions for the top priorities in greenhouse, temperate and tropical crops. The temperate priorities particularly benefit US interests and provide a new source of funding for domestic research. Global partners determined through earlier GLP training programs are now continuing on new residue projects to provide data to local authorities and Codex for product registration. The Minor Use Foundation is now coordinating and supporting much of this work, alleviating much of the burden that IR-4 carried to initiate and successfully bring this work to where it is today. Primary international organizations include IICA in Latin America, and APAARI in Asia. A new Codex MRL for pyriproxifen and sulfoxaflor in mango were established in 2021.

IR-4 has also become involved in capacity building projects in coordination with the Center of Excellence for Regulatory Science in Agriculture based at NC State. Training has focused on Central America and Asia to promote knowledge and regulatory harmonization, as well as import MRLs for US exports.

At the request of EPA, IR-4 personnel continue to be included as part of the US delegations to the Codex Committee on Pesticide Residues (CCPR). IR-4 plays a key role in these activities by supporting global standards and incentives that support minor uses. These include global recognition of crop grouping and extrapolation as well as promoting MRLs on specialty commodities.

While the in-person 52nd Session of the Codex Committee on Pesticide Residues (CCPR), scheduled for 30 March to 4 April 2020 in Guangzhou, China, was canceled due to COVID-19, the Electronic Working Group for Revision of the Classification of Food and Feed was re-initiated in November 2020, and the CCPR meeting was held virtually from 26-30 July and 3 August 2021. During this meeting CCPR agreed to forward the revised Class C: Primary animal feed commodities and the revised Class D: Processed food of plant origin and their respective tables of examples of representative commodities to Step 5/8 for adoption by CAC44.

IR-4 helped develop new initiatives in Asia and Africa on residue mitigation and biopesticide regulatory harmonization, both of which were funded as full proposal grants by the Standards Development and Trade Facility (STDF).

Plans for 2022

Food Use Residue Studies - The proposed 2022 Food Use Residue Program consists of 366 field trials. This trial plan includes 309 trials scheduled at IR-4 Field Research Centers/other University sites, 47 field trials at ARS sites and 10 field trials conducted by Canadian partners.

Food Use Product Performance Research - IR-4 is planning to conduct 97 food use field trials (all at state University sites) to develop product performance data for 41 different projects. Canadian partners at CN-PMC will also be contributing a number of efficacy and crop safety trials in several projects.

Integrated Solutions - The high priority projects for Integrated Solutions research in 2022 are shown in the table below. The 30 projects include 12 carry-over projects from the 2021 program and 18 new projects (includes 6 new projects supported by CDA) established as new priorities by IR-4 stakeholders. A total of 34 field trials are planned to support these projects (8 supported by CA funds and 26 supported by NIFA $).

Integrated Solutions #	Title
2021 Carry-over projects:	
IS00380	Bitter rot (*Colletotrichum* spp.) / Apple
IS00388	Nematode, sting (all species) / Strawberry
IS00399	Rust / Coffee
IS00002	Glyphosate resistant weeds / All crops
IS00390	Weed control / Cold-hardy small fruits
IS00389	Dormancy break / Grape
IS00393	Weeds / Date palm
IS00382	Mites / Hemp
IS00397	Thrips / Green onion
IS00166	Cabbage maggot / Brassica leafy greens crops
IS00376	Grape leafhopper / Grape
2022 New projects:	
IS00161	Fungi / Post harvest organic sweet potato
IS00100	Black rot (Xanthamonas) / Brassica leafy greens crops
IS00411	Root rot / Mung bean
IS00110	Phytophthora crown and fruit rot / Summer squash
IS00369	Oomycete pathogens (Pythium and Phytophthora) / Hemp
IS00420	Fruit thinning / Stone fruits
IS00401	Broadleaf, sedge, grass weeds / Organic rice
IS00402	Broadleaf, sedge, grass weeds / Wild rice
IS00370	Weed control / Hemp
IS00422	Glufosinate residue reduction / Hops
IS00403	Seed corn maggot / Parsnip
IS00415	Thrips / Tomato
IS00409	Whitefly / Squash
IS00026	Spotted wing drosophila / Berries
IS00408	Mites / Strawberry (field)
IS00405	Navel Orangeworm / Almond
IS00423	Olive fruit fly / Olive
IS00406	Black fig fly / Fig

Environmental Horticulture Program

The Environmental Horticulture Program continues to support an industry valued at nearly $19.2 billion in annual sales (Horticulture Census, 2019, NASS). This industry is quite complex because growers cover many diverse markets including flowers, bulbs, houseplants, perennials, trees, shrubs and more. These plants are grown and maintained in greenhouses, nurseries, commercial/residential landscapes, interiorscapes, Christmas tree farms and sod farms.

Research Activities

In 2021, IR-4 conducted 598 environmental horticulture research trials to support registrations in the greenhouse, nursery, landscape, Christmas tree and forestry industries. Of these, 233 were efficacy trials designed to compare different products to manage damaging insects, plant diseases and weeds; the remaining trials were conducted to determine the level of phytotoxicity to crops with these products. See Table 1 below for a summary of research activities, Attachment 7 for a complete listing of 2021 field cooperators and Attachment 8 for research activities listed by project.

Table 1. Summary of IR-4's 2021and Revised 2020 Environmental Horticulture Program Research Activities.

Category	2021			Revised 2020		
	Efficacy	Crop Safety	Total	Efficacy	Crop Safety	Total
Number of Studies (PR Numbers) with Planned Trials	155	255	410	216	270	486
Number of Trials	233	365	598	284	405	689

Submissions and Successes

During 2021, 20 data summaries were compiled based upon research reports submitted by researchers: Bacterial Disease Efficacy Summary - 2021, Beetle, Borer, Weevil & White Grub Efficacy Summary - 2021, Botrytis Efficacy Summary - 2021, Flumioxazin + Prodiamine Crop Safety - 2021, Flutianil Crop Safety - 2021, Fusarium Efficacy Summary - 2021, IKF-309 Crop Safety Summary - 2021, Indaziflam Crop Safety - 2021, Iron HEDTA Crop Safety - 2021, ISM-555 Crop Safety Summary - 2021, Isoxaben + Dithiopyr Crop Safety - 2021, Mandestrobin Crop Safety - 2021, Mefentrifluconazole Crop Safety Summary - 2021, Pendimethalin Crop Safety - 2021, Picarbutrazox Crop Safety - 2021, Pydiflumetofen + Difenoconazole Crop Safety Summary - 2021, Pydiflumetofen + Fludioxonil Crop Safety Summary - 2021, SP3014 Crop Safety - 2021, Thielaviopsis Efficacy Summary - 2021, and V-10433 Crop Safety Summary - 2021. See Attachment 9 for Abstracts from the individual reports. Data from 5,232 trials contributed to the writing of these reports. Table 2 below lists the number of trials by IR-4 Region that were used in the data summaries.

Table 2. 2021 Environmental Horticulture Program Research Summaries.

Region	Number of Trials
North Central	351
North East	489
Southern	1,015
Western	666
USDA-ARS	426
Total	2,949

During 2021, one new US EPA approval occurred for Postiva, and the Stargus label was amended in California (see Table 3 below).

Table 3. 2021 Environmental Horticulture Program Registration Contributions.

Category	2021			
	Efficacy	Crop Safety	Both	Total
New US EPA Product Registrations [a]	0	0	1	1
US EPA Label Amendments [b]	0	0	0	0
State Registrations [c]	1	0	0	1

International	0	0	0	0
Not to be Registered	0[g]	0	0	0[g]
Number of Trials Contributing to Registrations [d]				
North Central	-	-	-	2
North East	-	-	-	5
Southern	-	-	-	5
Western	-	-	-	5
USDA-ARS	-	-	-	14
Number of Impacted Crops [e]	1,500	11	-	1,511

[a] New products for the environmental horticulture industry based on data collected through IR-4 and submitted to manufacturers in previous years.

[b] Label updates on existing products for the environmental horticulture industry based on data collected through IR-4 and submitted to manufacturers in previous years.

[c] State registrations and special local needs registrations on federally registered products for the environmental horticulture industry based on data collected through IR-4 and submitted to manufacturers in previous years.

[d] The total number of trials where data was utilized for registrations.

[e] The number of impacted crops is an estimate of the total plant species grown commercially for environmental uses impacted by the IR-4 data.

[f] For some registrations, IR-4 contributed both efficacy and crop safety data.

2021 Workshop
The first virtual Environmental Horticulture Workshop was held September 28-30, 2021 to establish priorities for the 2022 and 2023 biennial research cycle.

Priorities from the 2021 Workshop include:

- Entomology Projects: Borer & Beetle Efficacy, Mealybug & Scale Efficacy, New Pest Management Tool Crop Safety
- Pathology Projects: Pythium & Phytophthora Efficacy, Non-Oomycete Root & Crown Rot Efficacy, New Disease Management Tool Crop Safety,
- Weed Science: Preemergent Herbicide Crop Safety, Postemergent Herbicide Efficacy, Nostoc Efficacy on Hard Surfaces
- Regional Projects:
    - NCR – Botryosphaeria Canker Efficacy, Botrytis Efficacy
    - NER – Fatty Acid Herbicide Efficacy, Thrips Efficacy
    - SOR – Bacterial Leaf Spots, Eriophyid Mite Efficacy
    - WSR – Botrytis Efficacy, Preemergent Herbicide Crop Safety for Field Production of Bulbs, Cut Flowers, Ornamental Grasses

Invasive Species Research Activities
During 2021, the IR-4 Environmental Horticulture Program received funding under USDA-APHIS Farm Bill Section 7721. The first project was studying mitigation options and improving diagnostics of impatiens and cucurbit downy mildews. The second project was developing preliminary eradication options, preparing a visual guide and screening mitigation tools for box tree moth, a new exotic pest that was discovered in Canada during 2018.

Pollinator Protection Activities
Protecting pollinators continues to be of public interest and is impacting decision making at many levels from individual consumers to the federal government. This research project is providing crucial, science-based information for this decision making and opportunities for the ornamental horticulture industry to contribute to improved pollinator health by growing plants using the best production practices, thereby increasing pollinator forage quality and quantity in rural and urban landscapes.

During the fifth year of this project, we maintained test garden plots of annual and perennial cultivars and collected/counted the visiting pollinators. We finished studies on the amount of systemic insecticides found in pollen and nectar with plots of rhododendron, sunflower, annual and perennial salvia, and snapdragon. We compiled the available efficacy and toxicology information for alternative treatment options, and we analyzed enterprise analysis budgeting provided by growers for costs with alternative tools. Our team wrote more than 8 scientific and 26 trade articles and gave more than 19 presentations to multiple audiences from K-12 students to scientific peers. Ultimately, these activities will improve pollinator health and conservation in urban and suburban areas and improve the sustainability and profitability of the ornamental horticulture and beekeeping industries.

Biopesticide and Organic Support Program

Regulatory Activities:
Interest in obtaining assistance from IR-4 in biopesticide registration continues to increase. A registration with an exemption from the requirement of a tolerance for residues of oxalic acid (§ 180.1381) on honey and honeycomb when oxalic acid is used as a miticide (Varroa mites) in honeybee hives was obtained in 2021.

A submission was made for Darling 58 American chestnut, which shows enhanced tolerance to the chestnut blight, caused by the fungus *Cryphonectria parasitica*. Darling 58 American chestnut expresses a wheat gene for oxalate oxidase, which degrades oxalic acid produced by the fungus and protects the tree from damage caused by this

pathogen. The proposed use practices include distribution programs for both horticultural and ecological restoration purposes, to enhance forest health and genetic diversity.

A submission was made for *Helicoverpa zea* nudivirus 2 (HzNV-2) strain 90IR71, which is a highly selective, virus that infects and sterilizes only the corn earworm *Helicoverpa zea* insect (also known as the cotton bollworm, tomato fruitworm and soybean podworm). Infected *Helicoverpa zea* pupae or moths are released near affected crops or the area where feral moths are present.

A submission was made for *Aspergillus flavus* strains TC16F, TC35C, TC38B and TC46G, which are non-aflatoxin-producing strains of *A. flavus*, and are proposed for application to corn to reduce the incidence of aflatoxin producing strains of *A. flavus* and thereby reduce aflatoxin contamination on all food and feed commodities of field corn, popcorn and sweet corn. These strains competitively exclude aflatoxin producing *A. flavus* strains without increasing *A. flavus* in the environment in the long term.

Pre-submission meetings with EPA were held for (1) dried cherries and larch arabinogalactan, a behavioral disruptor for spotted winged Drosophila; (2) for pongamia oil and (3) inerts for a new oxalic acid formulation.

Through funding by USDA-FAS, IR-4 developed a new biopesticide regulatory framework for Pakistan and submitted a dossier for AflaPak which utilizes atoxigenic Aspergillus flavus technology. The project has now started to expand onto chili pepper.

The Biopesticide Program is also part of a consortium of university and USDA scientists that were awarded a NIFA CAP Grant to provide regulatory support for EPA registration of peptides active against citrus greening.

Impact of IR-4 Activities

The IR-4 Project remains engaged in the approval of conventional crop protection chemicals. Almost all of the products tested in IR-4's research are chemicals classified by the US EPA as Reduced Risk or products that have more desirable characteristics regarding human health and environmental impact. The IR-4 Project has been a major contributor to the advancement of Integrated Pest Management (IPM) tactics through approval of crop protection tools that give producers suitable options to manage destructive pests that disrupt advanced IPM systems. In 2018, the IR-4 Project introduced the Integrations Solutions (IS) initiative. The IS initiative couples bio-based products with conventional products in a defined system whose objectives are to reduce chemical residues in food, provide a means to break up pest resistance to pesticides and in some cases, develop a lower risk solution to the most-difficult-to-manage pests.

Many believe that global climate change will fundamentally change the pest problems that threaten agriculture, including the production of quality climate friendly specialty crops. As we move forward, insects/mites, plant diseases, weeds and other pest management challenges will grow significantly as pests adapt to the climate change much faster than our abilities to manage them. The ever-increasing human population will need the science and service to discover the technology necessary to manage pests and the ability to test these products in order to assure they are safe and effective to use to protect the limited supply of quality food.

It is IR-4's charge that specialty crop growers/farmers have access to modern crop protection products to manage pests on their commodities. This helps them produce an abundance of high-quality food and ornamental crops needed and desired by consumers, helps growers remain profitable and contribute to our well-being and helps to bolster rural economies while respecting the environment. Food processors and food retailers benefit in having a consistent supply of high-quality produce and/or raw materials to meet consumer demand or keep their processing facilities open and operational. The public benefits through having an abundant choice of healthy vegetables, fruits, nuts and other foods available at reasonable prices, as well as having ornamental horticulture plants to enhance the landscape and environment. IR-4's actions also prevent food waste throughout the supply chain at the farm to the consumer.

To better ascertain the impact of IR-4's research and regulatory activities, Michigan State University's Center of Economic Analysis reported the economic impact of IR-4 Project's activities in the Food, Ornamental Horticulture and Biopesticide and Organic Support programs. 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."*** See https://ir4.cals.ncsu.edu/other/IR4%202017%20Impact%20Final.pdf for a full report of the IR-4 economic impact study.

Food security and the security of our food system are critical to the success of our nation. IR-4 is an important part of the US system that secures our food system from the threats of pests and diseases. IR-4's research and regulatory activities are proactively solving many other pest management issues facing specialty crop growers, including pest resistance to pesticides, pesticides being a barrier to trade, food waste and the resiliency of specialty crops to climate change. The IR-4 Project is a national agriculture research and service program that assists specialty crop farmers whose passion is to grow healthy food for Americans and others.

Congressional Appropriations and other funding

Many entities provide financial support for the research and regulatory activities of the IR-4 Project. Core funding for IR-4 is approx. $16.667 million and it comes from the following sources:

Source	Annual Amount	Administration	Program/Activities covered
USDA-Minor Crop Pest Management (IR4) Grant	$11.916 million	Competitive four-year grant awarded to NC State	All core IR-4 Project research programs and activities
USDA ARS	$3.170 million	Contribute to and support IR-4 research priorites	Funding of ARS scientists and activiies[3]
National Research Support Program (Multistate Research Grant)	$0.481 million	Competitive five-year grant awarded to NC State	Salaries/activities at IR-4 Headquarters
Various industry contributions	$1.100 million	Unrestricted donations to IR-4 Project	All IR-4 Project activities and expenses [4]

[3] USDA-ARS allocates a small amount of its Congressional Appropriation funds to support the salary and other expenses for USDA-ARS personnel involved with high priority IR-4 research projects within IR-4's Food Use and Environmental Horticulture programs. Participating ARS scientists are given specific research assignments that complement the on-going research of the scientists at the SAES. From these funds, USDA-ARS contributes about $105,000 to IR-4 Headquarters that funds Environmental Horticulture research at Rutgers Tree Fruit & Ornamental Research and Education Center, as well as cost of travel for IR-4 Quality Assurance Unit personnel to perform required on-site critical phase audits at ARS Field Research Centers.

[4] Crop Protection companies and commodity associations provided $1.15 million of unrestricted funds that are used to supplement other IR-4 funds. This includes performing additional field trials, analytical analyses, funding purchase supplies for research (e.g. GLP level sample bags), supplementing the cost of operations for IR-4 HQ, including additional expenses associated with the move to North Carolina State University, conducting the priority-setting workshops/other meetings and miscellaneous matters.

In addition, IR-4 receives funds for non-core activities such as funds ($514,190) from USDA-APHIS for invasive species in environmental horticulture crops.

In 2021, NIFA implemented a major change in processing the largest single source of funds for IR-4: the USDA-Minor Crop Pest Management grant. The grant was converted to a four-year grant with competition for funds in the first year with renewals in year 2-4. The grant is awarded to a single institution (NC State) and funds for operations are distributed via sub-awards to the regions. The biggest change is that the grant now allows the host institutions to collect up to 10% indirect cost recovery on the total direct cost of their portion of the grant. In the past, the NIFA grant was for two years and each unit (HQ and four Regions) submitted their own grant application and award, and no indirect costs were allowed.

The IR-4 Project Management Committee allocated the 2021 Minor Crop Pest Management funds as follows:

- $7.719 million distributed to the four IR-4 Regional offices and Headquarters for personnel, supplies, equipment; laboratory analysis and other core expenses;
- $2.366 million allocated for field trials that produce the necessary residue samples and product performance data;
- $544,0000 supported Environmental Horticulture research;
- $442,000 provided for the Integrated Solutions projects;
- $842,500 was kept by NIFA to help fund their operations.

Please note that there was no line item in the 2021 funding allocation for indirect costs. This was because NC State (prime award) and University of Florida, Michigan State University, University of Maryland Eastern Shore and University of California (sub awardees) all agreed to a one-time waiver of collection of the allowable indirect costs. They agreed as the process change went into place so late in planning for 2021 that it would have had a very large and disruptive outcome on IR-4.

In addition to the direct allocation of resources, IR-4 also receives significant in-kind contributions from multiple sources including:

- SAES/land grant universities by hosting IR-4 field research centers, analytical laboratories and management offices throughout the United States (estimated at nearly $6.0 million annually);
- EPA Pesticide Registration Improvement Act fee waivers (average approx. $6.0 million/annually);
- Crop protection industry (their in-kind contributions are about $12 million based on 1:1 match of NIFA funds);
- The government of Canada also makes significant in-kind contributions (>$500,000).

IR-4 funding from government and non-government sources has remained relatively flat over the past ten-years while research expenses and employee compensation continues to increase. To offset the decade of flat funding, the IR-4 Project continues to explore opportunities to cut expenses and/or increase efficiencies. Unfortunately, IR-4 has had to scale back its research efforts and research infrastructure to manage the fiscal shortfalls. It was not that long ago that IR-4 established nearly 80 new residue studies annually. In 2021, this number dropped to 48. There is a similar pattern in the Environmental Horticulture Program. In October 2021, the IR-4 Project Management Committee made a difficult decision to close the North Central Region Analytical Laboratory at Michigan State University based on the continued prospect of flat funding and the high likelihood that indirect cost payment would start in 2022. The laboratory operations will conclude approximately August 2022. In addition, IR-4 will be consolidating its Quality Assurance unit and reducing staff size by two people. Savings from the shutdown and consolidation will be reallocated to place new research in 2023 as well as providing existing units additional funds to take on additional workload. This modification will not impact the field operations of the North Central Region as key positions in this office remain fully functional and available to service stakeholder needs.

Future Directions

The cornerstone of IR-4 research and regulatory efforts is an open and transparent stakeholder-driven research prioritization process that provides direction to IR-4 to perform studies that address the most important pest management voids in specialty crop agriculture. The majority of priorities for 2022 research in the Food Use Program (including magnitude of the residue studies, product performance projects, Integrated Solutions projects and a few legacy Biopesticide research studies) were established during a virtual online workshop in September 2021 for the Food Program and October 2021 for the Environmental Horticulture Program. Nearly 275 people participated in the Food Program priority setting and 125 in the establishment of two-year priorities for the Environment Horticulture Program.

Flat budgets and limited fiscal resources continue to be the most critical challenge for IR-4. The IR-4 Commodity Liaison Committee and the Minor Crop Farmers Alliance continue to advocate for IR-4 to the U.S. Congress and others in government about the importance of IR-4 and the need to provide adequate resources. Actions included a Congressional Lunch and Learn, visits with Congressional Members and/or their staff, a meeting with the Branch Chief of the Agriculture Division of the Office of Management and Budget, multiple visits with USDA/SAES leadership, etc. Congressman Jimmy Panetta of California developed a "Dear Colleagues" letter to the House Appropriation Committee recommending an increase to $20 million annually. In spite of all of these efforts, IR-4 funding levels have remained unchanged.

Because of the on-going limitations associated with the pandemic and efforts needed to manage the relocation of IR-4 Headquarters, IR-4 delayed issuing a new strategic plan in 2021. IR-4 continues to operate according to the principles outlined in its current strategic plan; ***IR-4 Project - VISION 2020.*** IR-4 has started the data gathering for the next strategic plan. Specifically, the IR-4 Project Management Committee has established an ad hoc Path Forward 2.0 Committee to examine some of the tactical and strategic questions facing IR-4 and its operations. Much of the focus is on the role for IR-4 to ensure that growers, including growers following organic production practices, have access to effective tools to manage pests, with an understanding that resource constraints will limit IR-4's ability to meet the ever increasing and evolving demand for crop protection products for specialty crops and minor uses.

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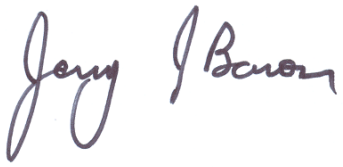
Vea, E. J. Cavaliere. 2021 Crop Vignette: Daylillies. Crop Vignette: Daylilies – IR-4 Project (ir4project.org)

December 31, 2021

Approved by:



J.J. Baron, Executive Director
IR-4 Project, North Carolina Agriculture Research Service
North Carolina State University

John Wise, Chair,
IR-4 Project Management Committee
Michigan State University

Douglas Buhler, Chair,
IR-4 Administrative Advisers
Michigan State University

ATTACHMENT 1 – Participants in the Process

Commodity Liaison Committee (CLC)

These are the primary customers for IR-4 Project services. A concerted effort is always made to seek input from growers/commodity group representatives for establishing research priority setting policies. The **IR-4 Commodity Liaison Committee (CLC)** provides input to the IR-4 Project Management Committee on overall operations and program direction. They are often effective communicators to Congress on the importance of the IR-4 Project and its deliverables to specialty crop agriculture in the United States. Members include:

Michael Aerts, Florida Fruit and Vegetable Association
Mark Arney, National Watermelon Promotion Board
Michael Bledsoe, Village Farms, L.P. and CLC Chair
Jennifer Clarke, California Leafy Greens Research Program
James R. Cranney, California Citrus Quality Council
Allison Crittenden, American Farm Bureau Federation
Alan DeYoung, Van Drunen Farms
William Frantz, Cranberry Institute
Amy Gandhi, Kemin Industries
Ann E. George, Washington Hop Commission
Zack Gihorski, National Association of State Departments of Agriculture
Jennifer Gray, Horticulture Research Institute
Bob Jones, The Chef Garden
Bob Kaldunski, Ginseng Board of Wisconsin
Armando Monterroso, Brooks Tropicals
Dennis Nuxoll, Western Growers Association
Keith Pitts, Marrone Bio Innovations
Amy Plato-Roberts, Lallemand Plant Care
Kan Quarles, National Potato Council
Rachel Roberts, American Mushroom Institute
Steven Salisbury, Mint Industry Research Council
Todd Scholz, USA Dry Pea & Lentil Council
Alan Schreiber, Agriculture Development Group, Inc.
Bob Simerly, National Onion Association
Berry Tanner, National Watermelon Association (alternative)
Dave Trinka, MBG Marketing
Amy Upton, Michigan Nursery & Landscape Association
Lee Van Wychen, Weed Science Society of America
Herman Waguespack, American Sugar Cane League

Cooperating Government Departments and Agencies

Agriculture and Agri Food Canada-Pest Management Centre (CN-PMC)
Health Canada-Pest Management Regulatory Authority (PMRA)
State Agricultural Experiment Stations/Land Grant Universities (SAES)
State of California Department of Pesticide Regulation (DPR)
U.S. Department of Agriculture, National Institute of Food and Agriculture (NIFA)
U.S. Department of Agriculture, Agricultural Research Service (ARS)
U.S. Department of Agriculture, Foreign Agriculture Service (FAS)
U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS)
U.S. Environmental Protection Agency (EPA)

Crop Protection Industry

ADAMA Ag Solutions Ltd.	K-I Chemical USA, Inc
Agbiome	Kemin Crop Technologies
Agbitech	Landis International
Agro Research International	Marrone BioInnovations, Inc.
Agrospheres	Neogen
Albaugh, Inc.	Neudorff
Amvac Chemical Corporation	Nichino America, Inc.
BASF Corporation	Nisso America, Inc
Bayer CropScience USA	Novasource.
Bayer Environmental Science	Nufarm Americas, Inc.
Belchim Crop Protection	OHP
BioHumaNetics	Oro Agri
BioSafe Systems	PureCrop1
Bioworks	Rainbow Treecare Scientific
Certis USA	STBIO
Cleary	SePro Corporation
Corteva Agriscience	Summit Agro
Engage Agro USA	Syngenta Crop Protection, Inc.
Everris dba ICL Specialty Fertilizers	TDA
FMC Corporation	TKI Novasource
Gowan Company	UPL NA Inc.
HumaGro	Valent USA, LLC
ISK Biosciences	Vestaron

Project Management Committee (PMC)

Dr. Jerry Baron#, IR-4 Project Headquarters – IR-4 Project Executive Director
Dr. Tom Bewick, USDA-NIFA - National Program Leader
Dr. Michael Bledsoe#, Village Farms, Inc. - CLC Chair
Dr. Douglas Buhler, Michigan State University – Administrative Advisor, North Central Region
Dr. John Davis, North Carolina State University - Administrative Advisor, Southern Region
Dr. Liwei Gu#, University of Florida – Regional Director, Southern Region.
Dr. Matt Hengel#, University of California, Davis - Regional Director, Western Region
Dr. Marcel Holyoak, University of California, Davis – Administrative Advisor, Western Region
Dr. Moses Kairo, University of MD Eastern Shore - Administrative Adviser, Northeast Region
Dr. Steven Lommel, North Carolina State University – Administrative Advisor
Dr. Joseph Munyaneza, USDA-ARS - Administrative Advisor
Dr. Alvin Simmons#, USDA-ARS – Director Minor Use Program
Dr. John Wise#, Michigan State University – Regional Director, North Central Region, and PMC Chair
Dr. Simon Zebelo#, University of MD, Eastern Shore - Regional Director, Northeast Region

#Voting member

IR-4 Project Headquarters (HQ)[5]

IR-4 Headquarters is located at 1730 Varsity Drive, Suite 210, Raleigh, NC 27606

Dr. Alice Axtell - Principal Entomologist
Mr. Bill Barney – Biopesticide Regulatory Manager
Dr. Jerry Baron – Executive Director
Mr. Roger Batts - Principal Weed Scientist
Ms. Susan Bierbrunner – Data Administrator (Rutgers Univ.)
Dr. Michael Braverman – Biopesticide/Organic Support Manager & Int'l Capacity Building (Rutgers Univ.)
Mr. James Byrtus – Research Assistant, Regulatory Sciences
Dr. Debbie Carpenter – Assoc. Director for Regulatory Sciences
Dr. Krystal Chojnacki - National Chief of Staff
Ms. Jane Forder – Quality Assurance Auditor
Ms. Jennifer Heiss – National Information and Communications Officer
Ms. Shiayi Huang - Data Applications Manager
Ms. Katherine Jaworski - Research Assistant, Research Planning
Ms. The'Shaun Jones – Business Services Coordinator
Ms. Cristina Marconi - Study Director
Dr. Johanna Mazlo - National Quality Assurance Unit Manager
Mr. Philip Moore - Study Director
Mr. Scott Muir - Quality Assurance Auditor
Dr. Cristi Palmer – Manager, Environmental Horticulture Program (Rutgers Univ.)
Dr. Venkat Pedibhotla – Assist. Director, Research Planning/Product Performance
Mr. Thomas Pike – Study Director
Dr. Dan Rossi - Senior Management Associate
Mr. David Schnatter - Business and Events Operations Assistant
Dr. Van Starner – Senior Management Associate
Ms. Juliet Thompson – Research Specialist, Quality Assurance
Mr. Robert Welker - Study Director

Field Coordinators (Regional and ARS)

Dr. Michael Horak, University of California, Davis – Western Region
Ms. Marylee Ross, University of Maryland – Northeast Region
Dr. Alvin Simmons, USDA-ARS – ARS Office of Minor Use Pesticides
Dr. Janine Spies, University of Florida – Southern Region
Dr. Anthony Van Woerkom, Michigan State University – North Central Region

Laboratory Coordinators (Regional and ARS)

Dr. Sue Erhardt, Michigan State University – North Central Region
Dr. Matt Hengel, University of California, Davis – Western Region
Dr. Gail Mahnken, University of Florida – Southern Region
Ms. Tamara Snipes, USDA-ARS – Tifton, GA
Mr. T. Todd Wixson, USDA-ARS – Wapato, WA

[5] Uta Burke, Kathryn Homa, Grace Lennon, Sherri Nagahiro and Karen Sims worked a partial year at IR-4 Project Headquarters at its formal site at Rutgers University.

Quality Assurance Unit

Dr. Martin Beran, University of California, Davis – Western Region
Dr. Zhongxiao (Michael) Chen, Michigan State University – North Central Region
Ms. Jane Forder, North Carolina State University – Northeast Region
Ms. Kathleen Knight, University of Florida – Southern Region
Ms. Lisa Latham, Michigan State University – North Central Region
Dr. Johanna Mazlo, North Carolina State University - Headquarters
Mr. Scott Muir, North Carolina State University - Headquarters
Ms. Sherita Normington, University of California, Davis - Western Region
Ms. Juliet Thompson, North Carolina State University – Headquarters
Dr. Yavuz Yagiz, University of Florida - Southern Region

Additional Technical Staff

Mr. Stephen Flanagan – Assistant Regional Field Coordinator, Western Region
Ms. Megan James – Field Coordinator Assistant, Northeastern Region
Ms. Nicole Soldan – Field Program Assistant, North Central Region
Ms. Mika Pringle Tolson – Assistant Regional Field Coordinator, Western Region

IR-4 State Liaisons Representatives

North Central Region

IA	Robert Hartzler
IL	Dave Williams
IN	Daniel Egel
KS	Ray Cloyd (EH)
MI	Anthony VanWoerkorn
MN	Vera Krischik
MO	R. Smeda
ND	Andrew Robinson
NE	Amit Jhala
OH	Doug Doohan
SD	Sharon Clay
WI	Dan Heider (Food) & Russel Groves (EH)

Northeast Region

CT	Jatinder Aulakh
DE	Brian Kunkel
NH	Vacant
NJ	Thierry Besancon
NY	Brian Nault
MA	Susan Scheufele
ME	Lily Calderwood
MD	Marylee Ross
PA	Greg Krawczyk
RI	Heather Faubert
VT	Vacant
WV	Carlos Quesada

Southern Region

AL	Edgar Vinson
AR	Nilda Burgos
FL	Peter Dittmar
GA	Stanley Culpepper
KY	Ric Bessin
LA	Tristan Watson
MS	Alan Henn
NC	David Monks
OK	Charles Luper
PR	Wilfredo Robles-Vazquez
SC	Matt Cutulle
TN	Zack Hansen
TX	Mark Matocha
VA	Daniel Frank

Western Region

AL	Phillip Kaspari
AZ	Alex Hu
CA	Michael Horak, Brad Hanson, Jim Adaskaveg
CO	Lisa Blecker/Jane Stewart
GU	Ross Miller
HI	Julie Coughlin
ID	Rhoda Hirnyck
MT	Zachary Miller
NM	Vacant (Rolston St. Hilaire, acting SLR)
NV	Maninder Kaur Walia
OR	Dani Lightle
UT	Corey Ransom
WA	Doug Walsh
WY	Bill Stump

Regional Field Research Scientists – Food Program

North Central Region				
Residue			Performance	
MI	S. Chaudhari, M. Hausbeck, A. Van Woerkom		IN	J. Beckerman, S. Meyers
OH	L. Horst*, A. Robinson		MI	S. Chaudhari, M. Hausbeck
SD	G. Reicks		ND	B. Jenks
WI	S. Chapman, D. Heider		OH	D. Doohan, A. Robinson
			SD	G. Reicks
			WI	D. Heider

Northeast Region				
Residue			Performance	
MD	M. James, M. Ross		DE	A. Koehler, D. Owens, M. VanGessel
NJ	J. Fisher, T. Freiberger, J. Hyland		MA	M. Sylvis, L. Uppala
NY	C. Dickenson, G. Jordan		MD	M. Hu
			NJ	T. Besancon
			NY	F. Faruque, C. Hoepting, D. Gilrein, T. Lessord, M. McGrath, B. Nault, T. D. Reed, L. Sosnoski, A. Taylor
			PA	K. Peter

Southern Region				
Residue			Performance	
FL	M. Frost, M. Long, D. Sutherland, Tannenbaum, D. Thomas		AL	K. Kesheimer, M. Samuel-Foo
GA	B. Fraelich*		FL	J. Beuzelin, N. Boyd, D. Carrillo, J. Crane, J. Desaeger, P. Devkota, P. Dittmar, R. Gazis, L. Kanga, C. Odero, R. Raid, G. Vallad
LA	K. Bourgeois, D. Wright		GA	P. Brannen
MS	T. Horn		KY	R. Bessin, N. Gauthier, R. Villanueva, B. Webb
NC	S. Smith, R. Welker		LA	B. Wilson
PR	W. Robles Vazquez		MS	M. Shankle
SC	P. Wade*		NC	H. Burrack, K. Jennings, R. Leon, L. Quesada, S. Villani
TX	M. Arias, T. Jones		PR	W. Robles Vazquez, R. Feliciano
			SC	K. Ling
			TN	Z. Hansen
			VA	T. Kuhar, D. Reed

Western Region				
Residue			Performance	
CO	C. Oman		CA	J. Adaskaveg, I. Grettenberger, B. Hanson, P. Mauk, J. Sidhu, S. Stoddard, G. Torres, T. Turini, Z. Wang, H. Wilson, R. Wilson
CA	S. Benzen*, D. Ennes, G. Kyser, N. Leach, K. Skiles,		CO	A. Szczepaniec

	B. Turner, S. Watkins			
HI	J. Coughlin, J. Kam		HI	J. Coughlin
ID	W. Meeks		MT	Z. Miller
OR	D. Lightle		OR	N. Andersen, C. Brunharo, K. Buckland, D. Gent, M. Moretti, C. Ocamb, E. Peachey
WA	D. Larson*, B. Maupin, W. Peng		WA	T. DuPont, D. Walsh, T. Waters

Canada				
Residue			Performance	
BC	M. Clodius			
NS	D. Hanscomb			
ON	R. Wismer, C. Szentimrey			
QC	J. Smaers			

ATTACHMENT 2 – 2021 Food Use Research Projects, New Residue Studies

Chemical	Crop	PR #
Acetamiprid	Dragon fruit	13057
Azoxystrobin	Basil (GH transplants)	13107
Azoxystrobin	Broccoli (GH transplants)	13111
Azoxystrobin	Spinach (GH transplants)	13110
Azoxystrobin	Tomato (GH transplants)	13105
Benzovindiflupyr	Cranberry	11811
Bicyclopyrone	Pineapple	11997
Broflanilide	Sugarcane	13167
Chlorantraniliprole	Lettuce (GH)	12514
Difenoconazole + Azoxystrobin	Olive	13099
Difenoconazole + Azoxystrobin	Spinach	13094
Dimethenamid-P	Pomegranate	13081
Ethalfluralin	Edamame	10952
Fenhexamid	Basil (GH transplants)	12062
Fludioxonil + Pydiflumetofen	Peach	12972
Flumetsulam	Clover (seed crop)	13062
Flumioxazin + Pyroxasulfone	Pepper (bell & nonbell)	12577
Flumioxazin + Pyroxasulfone	Tomato	12576
Fluoxapiprolin	Basil	13067
Fluoxapiprolin	Ginseng	13157
Flupyradifurone	Sugarcane	12987
Flutriafol	Tomato (GH)	10804
Glufosinate	Kiwifruit	12933
Glufosinate	Sunflower	13178

Isofetamid	Hemp	13007
Mefenoxam	Passionfruit	13046
Methoxyfenozide	Fig	12898
Oxathiapiprolin	Cherry	13141
Oxathiapiprolin + Mandipropamid	Carrot	13096
Oxathiapiprolin + Mandipropamid	Radish	13080
Paraquat	Stevia	12810
Penthiopyrad	Avocado	13075
Picarbutrazox	Ginseng	12606
Picarbutrazox	Hops	12848
Prothioconazole	Grasses (seed crop)	13195
Pyraziflumid	Tomato	13076
Quinclorac	Hazelnut	12721
Quizalofop	Hemp	13017
Saflufenacil	Mint	11921
S-Metolachlor/Metolachlor	Field pennycress	12868
S-Metolachlor/Metolachlor	Turnip greens	12818
Spidoxamat	Cucumber (GH)	13083
Spidoxamat	Pepper (GH)	13084
Spidoxamat	Tomato (GH)	13082
Spinetoram	Sesame	13132
Spinosad	Pea (succulent shelled) (seed trt)	13103
Sulphur dioxide	Fig	13183
Sulphur dioxide	Sweet potato (post harvest)	12521

ATTACHMENT 3 – 2021 Food Use Product Performance Research Program

Chemical	Crop	PR#	Comments	State university trial sites
Acetamiprid	Sunflower	12668	2019 residue study supports use on safflower; Mfg needs 2 sunflower weevil trials	SD, SD
Acetamiprid	Dragon fruit	13057	2021 residue study	FL
Acifluorfen	Basil	12791	2020 residue study	CA, FL
Bentazon + Acifluorfen	Dry pea	12841	2020 residue study	ND
Broflanilide	Sugarcane	13167	2021 residue study	FL, LA
Copper Hydroxide	Miracle fruit	12596	2021 H+ performance priority; need data to add crop to label	FL
Cyazofamid	Turnip roots	13015	2021 H+ performance priority; need E/CS data before residue	OR, OR
Florpyrauxifen-benzyl	Blueberry	13138	2021 H+ performance priority; need data to add crop to label	MI, NC, NJ, OR
Fluazinam	Grape	12715	2020 residue study	MD
Flumetsulam	Clover (seed crop)	13062	2021 residue study	OR
Flumioxazin + Pyroxasulfone	Cassava	11939	need E/CS data only	PR
Flumioxazin + Pyroxasulfone	Cucumber, summer squash, melon	12580 12581 12582	2021 H+ performance priority; need E/CS data before residue	DE, FL, NC, OH
Fluoxapiprolin	Basil	13067	2021 residue study	FL, NY
Fluoxapiprolin	Ginseng	13157	2021 residue study	MI
Glufosinate	Sweet potato	10558	need E/CS data before residue	MS, NC
Glufosinate	Kiwifruit	12933	2021 residue study	CA, CA, CA
Glufosinate	Safflower	13120	need data to add crop to label	CA, CA, CA
Glufosinate	Carambola	13049	2021 H+ performance priority; need data to add crop to label	FL, FL

Indaziflam	Asparagus	13026	2021 H+ performance priority; need E/CS data before residue	CA, MI, NJ, OR
ISM-555	Carrot	12614	need E/CS and residue data	CA, NY
Isofetamid	Hemp	13007	2021 residue study	KY, WI
Linuron	Green onion	12815	2020 residue study	MI, MI, OH
Linuron	Succulent bean	11772	2020 residue study	DE, DE, FL
Linuron	Brassica carinata	10974	2021 H+ performance priority; need E/CS data before residue	FL, NC
Mefenoxam	Passionfruit	13046	2021 residue study	FL
Paraquat	Sweet potato	12869	need E/CS data to add sweet potato to label; Subgroup 1C tolerance supports this crop	MS, NC
Penthiopyrad	Avocado	13075	2021 residue study	FL
Pyraziflumid	Tomato	13076	2021 residue study	CA
Pyridate	Basil	12843	need E/CS data before residue	CA, CA, CA, FL, MI, NJ
Quinclorac	Grape	12611	2021 H+ performance priority; need E/CS data before residue	CA, MI, NJ, NY, OR
Quizalofop	Dill	08690	2020 residue study	FL, MI
Saflufenacil	Mint	11921	2021 residue study	IN, IN, WI
S-metolachlor	Camelina	12867	2020 residue study	MT
Spinosad	Snap bean (seed trt)	13101	need E/CS data only	CA, NY, OR
Spinosad	Sweet corn (seed trt)	13104	need E/CS data only	CA, DE, OR
			Total	79

ATTACHMENT 4 – 2021 Submissions to EPA, Registrants, Codex, and State Departments of Agriculture

Pest Control Agent	Registrant	Type*	Date	Commodity or Crop Group	PR#
Tribenuron-methyl	FMC, NUFARM	H	01/13/2021	Individual commodities of proposed Dried shelled bean, except soybean, subgroup 6-18E Individual commodities of proposed Dried shelled pea, subgroup 6-18F Rapeseed subgroup 20A Cottonseed subgroup 20C Individual commodities of proposed Wheat subgroup 15-20A Individual commodities of proposed Barley subgroup 15-20B Individual commodities of proposed Field corn subgroup 15-20C Individual commodities of proposed Grain sorghum and millet subgroup 15-20E Individual commodities of proposed Rice subgroup 15-20F	11980 12245 13187 13188 13189 13190 13191 13192 13193
Cyclaniliprole	ISK	I	01/21/2021	Artichoke (globe) Pepper/Eggplant subgroup 8-10B Tomato subgroup 8-10A Sunflower subgroup 20B	11952 11891 11894 11570 12264
Pyriofenone	ISK	F	01/25/2021	Cucumber (greenhouse) Pepper/Eggplant subgroup 8-10B Tomato subgroup 8-10A	11446 11447 11448
Fluazifop-p-butyl	SYNGEN	H	02/03/2021	Brassica, leafy greens, subgroup 4-16B Vegetable, brassica, head and stem, group 5-16 Leaf petiole vegetable subgroup 22B Onion, green, subgroup 3-07B Chive, dried leaves Papaya Fruit, citrus, group 10-10 Fruit, stone, group 12-12 Berry, low growing, subgroup 13-07G	A2076 02332 02334 03027 03245 03246 02327 02338 11861 11862 02336 A2087 11265 11363 11364 13198
Propiconazole	SYNGEN	F	02/15/2021	Vegetable, brassica, head and stem, group 5-16	11586 11587
Isofetamid	ISK	F	03/03/2021	Ginseng Individual crops of proposed crop subgroups 6-19A, 6-19B, 6-19C, 6-19D, 6-19E, 6-19F	12000 13206 13207 13208

					13209 13210 13211
Pydiflumetofen	SYNGEN	F	04/23/2021	Caneberry subgroup 13-07A Vegetable, fruiting, group 8-10 Lettuce (greenhouse) (in support of label change)	11794 11879 11880
Rimsulfuron	CORTEVA	H	05/18/2021	Pomegranate Tropical and subtropical, small fruit, edible peel, subgroup 23A	10606 10184
Trifloxystrobin	BAYER	F	06/04/2021	Onion, bulb, subgroup 3-07A Onion, green, subgroup 3-07B Individual commodities of proposed subgroup 6-18A: Edible podded bean legume vegetable subgroup Individual crops of proposed subgroup 6-18E: Dried shelled bean, except soybean, subgroup Individual crops of proposed subgroup 6-18F: Dried shelled pea subgroup Brassica, leafy greens, subgroup 4-16B Celtuce Florence fennel Fruit, citrus, group 10-10 Fruit, pome, group 11-10 Fruit, stone, group 12-12 Kohlrabi Leafy greens subgroup 4-16A Leaf petiole vegetable subgroup 22B Nut, tree, group 14-12 Spice group 26 Vegetable, brassica, head and stem, group 5-16 Vegetable, fruiting, group 8-10	07049 A7049 09916 13235 13236 13227 13238 13239 13229 13230 13231 13240 13233 13232 13234 13228 13226 13237
Fluopyram	BAYER	F	06/16/2021	Brassica, leafy greens, subgroup 4-16B Celtuce Coffee Florence fennel Kohlrabi Leafy greens subgroup 4-16A Leaf petiole vegetable subgroup 22B Papaya Peppermint Spearmint Spice group 26 Vegetable, brassica, head and stem, group 5-16 Individual crops of proposed subgroup 6-18A: Edible podded bean legume vegetable subgroup Individual crops of proposed subgroup 6-18B: Edible podded pea legume vegetable subgroup Individual crops of proposed subgroup 6-18C: Succulent shelled bean subgroup Individual crops of proposed subgroup 6-18D: Succulent shelled pea subgroup	13250 13254 12758 13255 13249 13252 13253 10765 11971 11971 13251 13248 13243 13244 13245 13246 13247

				Individual crops of proposed subgroup 6-18E: Dried shelled bean, except soybean, subgroup	
Dodine	UPL	F	07/02/2021	Olive, with pit Fruit, pome, group 11-10 Fruit, stone, group 12-12 Nut, tree, group 14-12	13126 13268 13269 13270
Zeta-cypermethrin	FMC	I	07/02/2021	Cherry	12259
Kasugamycin	ARYSTA	B	07/06/2021	Olive, with pit	12656
Penthiopyrad	CORTEVA	F	09/10/2021	Banana Leafy greens subgroup 4-16A	11307 11444
Fomesafen	SYNGEN	H	09/29/2021	Vegetable, bulb, group 3-07 Vegetable, cucurbit, group 9 Vegetable, foliage of legume, except soybean, subgroup 7A Vegetable, fruiting, group 8-10	11620 13300 12467 13299
Glufosinate	BASF	H	10/19/2021	Tropical and subtropical, medium to large fruit, edible peel, subgroup 23B Tropical and subtropical, medium to large fruit, smooth, inedible peel, subgroup 24B Tropical and subtropical, small fruit, inedible peel, subgroup 24A Grass, forage Grass, hay	10242 12050 10239 12109 12109
Mandestrobin	VALENT	F	10/15/2021	Vegetable, tuberous and corm, except potato, subgroup 1D	12522
Trinexapac-ethyl	SYNGEN	P	11/03/2021	Clover, forage Clover, hay	11526 11526
Fluxapyroxad	BASF	F	12/21/2021	Coffee Stevia	13186 12535
Pyraclostrobin	BASF	F	12/21/2021	Coffee Stevia	13186 12535

ATTACHMENT 5 – 2021 Tolerance Successes - Permanent Tolerances Published in the Federal Register

Pest Control Agent	Registrant	Type *	Date	Commodity or Crop Group	Note	PR#	# of Uses	# of Tolerances
Benzovindiflupyr	SYNGEN	F	02/09/2021	Blueberry, lowbush Ginseng		12636 11760	1 1	1 1
Streptomycin	ADAMA, AGROSO, NUFARM	B	02/09/2021	Citrus, fruit, group 10-10		10043 11189	28	2
Clopyralid	CORTEVA	H	02/17/2021	Caneberry subgroup 13-07A Onion, bulb, subgroup 3-07A Wheatgrass		05147 11600 12748	5 11 1	1 1 7
Quizalofop	AMVAC, GOWAN	H	03/08/2021	Brassica carinata Cottonseed subgroup 20C Fruit, pome, group 11-10 Fruit, small, vine climbing, except fuzzy kiwifruit, subgroup 13-07F Fruit, stone, group 12-12 Pennycress (seed) Sunflower subgroup 20B	 2 2	12335 12686 10032 10033 10031 10034 10035 10036 12630 12685	1 0 12 6 22 1 13	2 1 1 1 1 1 1
Spinetoram	CORTEVA	I	04/07/2021	Berry, low growing, except strawberry, subgroup 13-07H Celtuce Dragon fruit Florence fennel Kohlrabi Leaf petiole vegetable subgroup 22B Vegetable, brassica, head and stem, group 5-16 Vegetable, leafy, group 4-16	2 4 4 4 1 1 1	12736 12737 11514 12738 12739 12734 12732 12733 12735	7 0 1 0 0 3 0 35	1 1 1 1 1 1 1 1
Spinosad	CORTEVA	I	04/07/2021	Berry, low growing, except strawberry, subgroup 13-07H Celtuce Dragon fruit Florence fennel Kohlrabi Leaf petiole vegetable subgroup 22B Vegetable, brassica, head and stem, group 5-16 Vegetable, leafy, group 4-16	2 4 4 4 1 1 1	12747 12744 11514 12745 12746 12742 12740 12743	7 0 1 0 0 3 0 35	1 1 1 1 1 1 1 1
MCPA	LOVLND, NUFARM	H	04/13/2021	Tea Wheatgrass, intermediate		12478 12377	1 1	1 4

Fluxapyroxad	BASF	F	07/13/2021	Cottonseed, subgroup 20C		12942	0	1
				Fruit, pome, group 11-10		12941	5	1
				Pomegranate		11754	1	1
				Vegetable, fruiting, group 8-10		12940	12	1
Zeta-cypermethrin	FMC	I	08/04/2021	Basil, fresh leaves		08397	1	1
				Basil, dried leaves		08397	1	1
				Onion, bulb, subgroup 3-07A		12872	10	1
				Onion, green, subgroup 3-07B		12873	14	1
				Leafy greens subgroup 4-16A		12874	17	1
				Leaf petiole vegetable subgroup 22B		12875	3	1
				Brassica, leafy greens, subgroup 4-16B		12876	12	1
				Vegetable, brassica, head and stem, group 5-16		12877	0	1
				Vegetable, fruiting, group 8-10		12878	11	1
				Orange subgroup 10-10A		12879	3	1
				Lemon/Lime subgroup 10-10B		12879	9	1
				Grapefruit subgroup 10-10C		12879	2	1
				Fruit, pome, group 11-10		12880	5	1
				Fruit, stone, group 12-12		12881	11	1
				Caneberry subgroup 13-07A		12882	1	1
				Bushberry subgroup 13-07B		12883	14	1
				Fruit, small, vine climbing, except fuzzy kiwifruit, subgroup 13-07F		12884	5	1
				Nut, tree, group 14-12		12885	25	1
				Rapeseed subgroup 20A		12886	0	1
				Sunflower subgroup 20B		12887	1	1
				Cottonseed subgroup 20C		12888	0	1
				Kohlrabi		12889	0	1
				Celtuce		12890	0	1
				Fennel, Florence, fresh leaves and stalk		12891	0	1
				Quinoa		12644	1	3
				Teff		12786	1	4
				Individual crops of proposed subgroup 6-18A: Edible podded bean legume vegetable subgroup		12892	17	1
				Individual crops of proposed subgroup 6-18B: Edible podded pea legume vegetable subgroup		12893	3	1
				Individual crops of proposed subgroup 6-18C: Succulent shelled bean subgroup		12894	17	1
				Individual crops of proposed subgroup 6-18D: Succulent shelled pea subgroup		12895	2	1
				Individual crops of proposed subgroup 6-18E: Dried		12896	25	1

				shelled bean, except soybean, subgroup				
				Individual crops of proposed subgroup 6-18F: Dried shelled pea subgroup		12897	6	1
Pyraclostrobin	BASF	F	09/20/2021	Pomegranate		11754	1	1
Fluazinam	ISK, SYNGEN	F	09/20/2021	Individual crops of proposed subgroup 6-19A: Edible podded bean legume vegetable subgroup	1	12946	17	1
				Individual crops of proposed subgroup 6-19B: Edible podded pea legume vegetable subgroup		12947	10	1
				Individual crops of proposed subgroup 6-19C: Succulent shelled bean subgroup	1	12948	17	1
				Individual crops of proposed subgroup 6-19D: Succulent shelled pea subgroup		12949	6	1
				Individual crops of proposed subgroup 6-19E: Dried shelled bean, except soybean, subgroup	1	12950	25	1
				Individual crops of proposed subgroup 6-19F: Dried shelled pea subgroup		12951	8	3
				Tomato subgroup 8-10A		10592	11	1
				Papaya		12480 08274	1	1
				Vegetable, brassica, head and stem, group 5-16, except cabbage	1	12944	0	1
				Brassica, leafy greens, subgroup 4-16B	1	12943	13	1
				Kohlrabi	4	12945	0	1
Thiabendazole	SYNGEN	F	09/02/2021	Vegetable, tuberous and corm, except sweet potato, subgroup 1C	2	12911	15	1
				Sweet potato, tuber		11859	1	1
				Brassica, leafy greens, subgroup 4-16B		11585	20	1
				Animal feed, nongrass, group 18		11310	10	1
				Vegetable, brassica, head and stem, group 5-16	1	12912	0	1
				Fruit, citrus, group 10-10	1	12913	14	1
				Fruit, pome, group 11-10	1	12914	5	1
				Vegetable, root, except sugar beet, subgroup 1B, except carrot	6	12915	0	1
				Carrot, roots		12916	0	1
Fluensulfone	ADAMA	N	11/01/2021	Brassica, leafy greens, subgroup 4-16B	1	13038	13	1

				Celtuce Fennel, Florence, fresh leaves and stalk Kohlrabi Leaf petiole vegetable subgroup 22B Leafy greens subgroup 4-16A Vegetable, brassica, head and stem, group 5-16	4 4 4 1 1 1	13042 13043 13041 13040 13039 13037	0 0 0 3 18 0	1 1 1 1 1 1
MCPA	LOVLND, NUFARM	H	12/15/2021	Clover		11994	1	2
						Totals	640	115
*F=fungicide, H=herbicide, I=insecticide/acaricide, M=molluscide, N=nematicide, P=plant growth regulator								

[1] Update of established tolerance on old crop group or subgroup

[2] Conversion of established tolerance(s) on representative commodities to a crop group or subgroup tolerance

[3] Conversion of established tolerance(s) on representative commodities *and* submission

submission of new data to complete the requirements for a crop group or subgroup

[4] Individual commodity tolerance established in response to crop group revision

[5] Response to EPA request for Codex harmonization

[6] Revised tolerance

[7] Tolerance for indirect or inadvertent residues

ATTACHMENT 6 – 2021 Environmental Horticulture Program Researchers

IR4 Region	Name
North Central	Dr. Janna Beckerman
	Dr. Douglas Doohan
	Dr. Francesca Hand
	Dr. Mary Hausbeck
	Ms. Erica Hotchkiss
	Dr. Hannah Mathers
	Dr. Marisol Quintanilla
	Dr. Debalina Saha
Northeast	Dr. Nora Catlin
	Dr. Diana Cochran
	Dr. Dan Gilrein
	Dr. Andy Senesac

Southern	Dr. Karla Addesso
	Dr. Fulya Baysal-Gurel
	Dr. JC Chong
	Dr. Jeffrey Derr
	Dr Steve Frank
	Dr. Mengmeng Gu
	Dr. David Held
	Mr. Jonathan Larson
	Dr. Chris Marble
	Dr. Inga Meadows
	Dr. Joe Neal
	Dr. Dave Norman
	Dr. Daniel Potter
	Dr. Erfan Vafaie

	Sr. Shimat Villanassery Joseph
	Dr. Anthony Witcher
USDA-ARS	Mr. Dave Bodine
	Mr. Ben Fraelich
	Dr. Nik Grunwald
	Mr. Duane Larson
	Dr. Mike Reding
	Mr. Paul Wade
Western	Dr. Gary Chastagner
	Dr. Zhiqiang Cheng
	Dr. Akif Eskalen
	Dr. Cai-Zhong Jiang
	Dr. Jim Klett

	Dr. Marcelo Moretti
	Dr. Christian Nansen
	Dr. Ed Peachey
	Dr. Luisa Santamaria
	Dr. Steven Seefeldt
	Dr. Buzz Uber
	Mr. Benjamin Nyman

ATTACHMENT 7 – 2021 Environmental Horticulture Program Research Activities

Discipline	Project	Researchers	Crops	Products	Trials
Entomology	Afidopyropen (BAS 440I) Crop Safety	2	2	1	2
Entomology	BCS991 Crop Safety	1	5	1	5
Entomology	Beauveria bassiana Crop Safety	2	4	1	4
Entomology	Borer & Beetle Efficacy	4	4	10	25
Entomology	Cyclaniliprole + Flonicamid Crop Safety	2	3	1	5
Entomology	ISM-555 Crop Safety	7	8	1	12
Entomology	Lepidopteran Efficacy	2	1	5	10
Entomology	Mealybug Efficacy	3	4	8	24
Entomology	Neem oil + Azadiractin Crop Safety	2	6	1	8
Entomology	Rosemary Oil Crop Safety	2	1	2	4
Entomology	Scale Efficacy	3	3	8	16
Entomology	SP3014 Crop Safety	3	3	1	3

Entomology	Thrips Efficacy	3	3	7	17
Entomology	V-10433 Crop Safety	3	4	1	4
Pathology	Bacterial Efficacy	1	1	9	9
Pathology	Botrytis Efficacy	1	1	8	8
Pathology	Cylindrocladium Efficacy	1	2	7	7
Pathology	Downy Mildew Efficacy	1	1	13	16
Pathology	F6123 Crop Safety	7	13	1	26
Pathology	Fluazaindolizine Crop Safety	3	4	1	5
Pathology	Fluopyram (ESP 715) Crop Safety	2	4	1	6
Pathology	Fluopyram + Trifloxystrobin Crop Safety	4	13	1	17
Pathology	Flutianil Crop Safety	7	10	1	12
Pathology	Fusarium Efficacy	1	1	8	8
Pathology	IKF-309 Crop Safety	5	12	1	15
Pathology	Mandestrobin Crop Safety	3	5	1	5

Pathology	Mefentrifluconazole (BAS 750) Crop Safety	3	12	1	24
Pathology	Nematode Efficacy	2	3	7	14
Pathology	Picarbutrazox Crop Safety	5	7	2	14
Pathology	Powdery Mildew Efficacy	2	2	11	20
Pathology	Pydiflumetofen + Difenoconozole Crop Safety	5	8	1	16
Pathology	Pydiflumetofen Crop Safety	1	1	1	1
Pathology	Pythium Efficacy	3	3	8	24
Pathology	Rhizoctonia Efficacy	1	2	7	7
Pathology	SP2478 Crop Safety	5	7	1	17
Pathology	SP2700 Crop Safety	7	6	2	9
Pathology	TDA01 Crop Safety	2	3	1	5
Pathology	Thielaviopsis Efficacy	1	1	7	7
Pathology	XDE-659 Crop Safety	2	2	1	3
Weed Science	Bentazon Crop Safety	4	9	1	12

Weed Science	Clopyralid Crop Safety	6	9	2	22
Weed Science	Dimethenamid-p Crop Safety	5	8	1	10
Weed Science	Dithiopyr Crop Safety	3	6	1	6
Weed Science	Fatty Acid Herbicide Use Directions	1	1	2	6
Weed Science	Flumioxazine + Prodiamine Crop Safety	7	15	1	26
Weed Science	Indaziflam Crop Safety	9	17	1	21
Weed Science	Iron HEDTA Crop Safety	3	6	1	7
Weed Science	Isoxaben + Dithiopyr Crop Safety	1	1	1	1
Weed Science	Isoxaben Crop Safety	5	8	1	11
Weed Science	Liverwort Efficacy	1	1	1	6
Weed Science	Nostoc Efficacy	2	1	6	9
Weed Science	Pendimethalin + Dimethenamid-p Crop Safety	3	3	1	3
Weed Science	Pendimethalin Crop Safety	5	9	1	11
Weed Science	Prodiamine + Isoxaben Crop Safety	3	8	1	11

For a detailed list of research activities visit https://www.ir4project.org/ehc/.

ATTACHMENT 8 – Environmental Horticulture Research Summaries for 2021

Borers, Beetles, and White Grub Efficacy

Collectively, managing coleopteran insects can be challenging because the adult and larval stages may both cause damage and sometimes occur on different hosts or on different plant parts. While organophosphates, pyrethroids, and neonicotinoids can provide good to excellent control of coleopteran insects, not all products work equally well in all situations. Treatments for borers are very different than treatments targeting white grubs. Developing newer classes of chemistry are important to reduce the environmental consequences and to minimize the development of resistance. Starting with the 2004 Annual Workshop, screening a number of products to manage coleopteran insects became one of the high priority projects for entomology. From 2005 through 2019, 78 products representing 53 different active ingredients were tested for management of adult and larval stages of coleopteran insects. In addition, 10 products representing 10 active ingredients were evaluated for lepidopteran clearwing borers in 2008 and 2009. These products represented both biological and chemical tools. Some products were already registered but more data were needed, or they were considered standards to measure the level of efficacy achieved with other materials. Other products were in development but have not yet been registered with the EPA. While a number of coleopteran and lepidopteran species were tested, only enough experiments were able to be completed on the coleopteran species black vine weevil, Japanese beetle, oriental beetle, Sri Lankan weevil, and viburnum leaf beetles to recommend actions to register or amend labels for these pests.

Bentazaon Crop Safety

Basagran T/O has been registered for several years as a directed application and as an over-the-top application on limited plant species. However, growers have expressed the need to have additional plants added for over-the-top applications. Data collected throughout the history of the IR-4 Environmental Horticulture Program are presented here to support specific Basagran T/O applications over the top of certain ornamental horticulture plants. The rates chosen for this research were 1.0, 2.0 and 4.0 pounds active ingredient per acre (lb ai per A) as the 1X, 2X and 4X rates. In addition, early studies compared single versus two consecutive applications of 1.0 lb ai per A or 2.0 lb ai per A followed with 1 lb ai per A. Throughout the years, 90 different crop species/genera were examined for over-the-top applications. Of these, 22 exhibited no or minimal transient injury after application at all three rates. Twenty-six crops require further research because of unclear results. Thirteen crops exhibited no phytotoxicity at 1.0 lb ai per acre but did have some injury at the higher rates or with repeat applications. Thirty species exhibited phytotoxicity at even the 1.0 lb ai per acre rate.

Bittercress Efficacy

Nursery growers have had a longstanding battle to control weeds in environmental horticulture crops. Bittercress (*Cardamine spp.*) is one of the most difficult weeds to control in container grown ornamentals. It grows aggressively in containers and can outcompete ornamental crops for water, nutrients, and light. Several chemical tools are available for preemergent control. However, there remains a need for effective control of emerged weed seedlings. At the 2007 Environmental Horticulture Workshop, IR-4 initiated a study to determine whether preemergent herbicides could provide efficacy for bittercress, and other weeds, up to the 2-4 leaf stage. Research was conducted from 2008 through 2019. This report is a brief summary of available data from 18 experiments received through the IR-4 Environmental Horticulture Program. Early postemergence applications of Casoron, Certainty, Gallery, Marengo/Indaziflam, and V-10142 provided significant control of emerged bittercress. These findings benefit growers by identifying select preemergence herbicides which control specific weeds at early emergence stages in container grown ornamental horticulture crops.

Botrytis Efficacy

At the IR-4 Environmental Horticulture Program Workshop in 2011, Botrytis Efficacy was selected as a high priority project to expand the knowledge and list of fungicides available to growers for these diseases. In addition to research collected through the IR-4 Program, this summary includes a review of experiments conducted from 1998 to 2019 on

environmental horticulture crops. During this time period, numerous products representing 54 active ingredients were tested as foliar applications against several *Botrytis* species causing blight and gray mold on multiple environmental horticulture crops. Most products are now registered and commercially used. Almost all trials were conducted on *Botrytis cinerea*; other species tested were *B. elliptica*, *B. paeoniae* and *B. tulipae.* Although there were insufficient IR-4 data for definitive conclusions, seven relatively new products that are included in this research project, Orkestra Intrinsic, Mural and Emblem (NUP 09092), Rhapsody/Serenade, Astun/IKF 5411, Picatina, and Picatina Flora looked effective, while Botector, BW165N, Proud 3, SP2480, SP2770 and SP2773 looked ineffective. Data on other relatively new products (Broadform, EcoSwing, F9110, MBI-110, Oxiphos, PreStop, Prophytex, Regalia, S2200, Torque, Tourney, Trinity) were limited to provide some conclusions. Of the established registered products, Compass, Daconil, Decree, Heritage, Insignia, Pageant and Palladium generally provided excellent efficacy; Chipco 26019 and Veranda O provided good efficacy and Disarm provided mediocre efficacy. ZeroTol, and the copper products (Badge X2, Camelot, Phyton 27, STBX-304) generally performed poorly under the conditions of these experiments.

Cyclaniliprole + Flonicamid Crop Safety

Pradia (cyclaniliprole + flonicamid) is a new insecticide combination recently registered for environmental horticultural crops for the control of a wide variety of insects including aphids, leafminers, scales and mealybugs, foliage feeding beetles and caterpillars, thrips, and whiteflies. In 2019, the IR-4 Project completed 16 crop safety trials on 9 ornamental plant genera or species. In these trials, 2 exhibited minimal or no injury after foliar applications. For the remaining 7 crops, sufficient information has not yet been generated. However, all tested crops are not sensitive to foliar applications up to 4X the proposed high label rate.

Dimethenamid-p Crop Safety

From 2007 to 2019, IR-4 completed 549 trials on Tower EC (dimethenamid-p). The data contained in this report was generated to register uses of dimethenamid-p on and around environmental horticulture plants with over-the-top applications. The dimethenamid-p rates in the testing program were 0.97, 1.94 and 3.88 pounds active ingredient per acre (lb ai per A) as the 1X, 2X and 4X rates. Tower EC had been applied to 154 plant genera or species. Of these, 65 plant species exhibited no or minimal transient injury after application at all three rates. Twenty four (24) crops exhibited no phytotoxicity at 0.97 lb ai per acre but did have some injury at 1.94 and 3.88 lb ai per acre. Ten crops – *Aquilegia sp., Catharanthus roseus, Cladrastis sp.*, *Echeveria sp.*, *Echinacea sp.*, *Epilobium canum, Muhlenbergia dubia, Rudbeckia hirta, Teucrium chamaedrys* and *Viburnum opulus* – exhibited significant phytotoxicity at even the lowest rate.

F6123 Crop Safety

F6123 is a new fungicide being developed by FMC for the control of powdery mildew, rusts, scab, black spot (*Diplocarpon rosae*), and other foliar diseases. The IR-4 Project completed 25 crop safety trials on 13 environmental horticulture plant species or genera during 2019 to 2020. At this time, sufficient information has not yet been generated for reliable conclusions on F6123 crop safety. In these limited number of trials, F6123 applied foliar caused minimal or no injury in 12 species or genera; however, drench application caused significant injury in 8 species or genera.

Fenamidone Efficacy/Crop Safety

From 2004 to 2012, fenamidone (FenStop, FenStar) was screened through the IR-4 Program as drench or foliar applications for effacay against nine *Phytophthora* species causing root rots and stem/leaf blights (*P. cactorum*, *P. cinnamomi*, *P. citricola*, *P. cryptogea*, *P. drechsleri*, *P. nicotianae*/*parasitica, P. ramorum*, *P. syringae,* and *P. tropicalis*), five Pythium species (*P. aphanadermatum*, *P. dissotocum*, *P. irregulare*, *P. ultimum*, and *P. vipa*), and two downy mildews (coleus, snapdragon). Efficacy ranged from highly effect to similar to nontreated inoculated controls depending on pathogen, host, and level of disease pressure. Based on findings it is recommended the following specific diseases be added to fenamidone labels: Coleus downy mildew, *Phytophthora cryptogea,*

Phytophthora nicotianae, Phytophthora ramorum, Phytophthora cinnamomi, Pythium aphanadermatum, Pythium mamillatum, Pythium ultimum, and Snapdragon downy mildew. Currently, the FenStop/FenStar label is limited to greenhouse use. It is recommended this be expanded to include outdoor use patterns.

Fluopyram Crop Safety

Indemnify (fluopyram) is a new fungicide being developed by Bayer for the control of nematodes; the current product is only registered for turf uses. The IR-4 Project has completed 37 crop safety trials on 18 environmental horticulture plant species or genera. Two crops (begonia, petunia) exhibited differential responses between foliar and drench applications with no to slight injury observed with foliar sprays, but moderate to severe injury with soil drenches. Four additional crops also did not exhibit injury after foliar or soil applications. Additional data are needed for 12 other crops (including foliar application on petunia) are needed for a definitive conclusion on crop safety.

Fusarium Efficacy

From 2001 to 2019, numerous products representing 40 active ingredients were evaluated in greenhouse and field trials as soil drench, soil incorporation, foliar,in-furrow, drip irrigation or tuber soak applications against several *Fusarium* species causing rots (crown, stem and tuber rots) and wilt on ornamentals, and wilt and root rot on vegetables. *Fusarium* species tested included: *F. avenaceum, F. commune, F. oxysporum, F. solani* and *F*. sp. Most trials were conducted on *F. oxysporum* on larkspur, liriope, lisianthus and watermelon. Although there were insufficient data for definitive conclusions, several relatively new products showed promising, though inconsistent, efficacy comparable to the standards. These include Picatina/Adepidyn/Miravis (pydiflumetofen), Heritage (azoxystrobin), Compass (trifloxystrobin), Hurricane (fludioxonil+mefenoxam), Insignia (pyraclostrobin), Insimmo (acibenzolar), Postiva/Miravis Duo (pydiflumetofen + difenoconazole), SP2169, Tourney (metconazole) and Trinity (triticonazole). Astun, Broadform, BW240/RootShield Plus (*Trichoderma harzianum & T. virens*), CG100 (caprylic acid), Mural, Orkestra, Pageant (boscalid+pyraclostrobin), Palladium (cyprodinil+fludioxonil) and SP2550 provided no to mediocre efficacy. Proline (prothioconazole) provided consistently good control of *F. oxysporum* in watermelon trials. The established standards 3336, Medallion and Terraguard generally provided inconsistent efficacy.

Halosulfuron Crop Safety

Since 1995, IR-4 has completed 391 trials with products containing halosulfuron (Sedgehammer, Manage) on 137 crops. The data contained in this report were generated to expand the current SedgeHammer label to include both directed and over the top applications on certain plant species along with adding nursery production sites. The halosulfuron rates in the 2006 and 2007 testing program were 0.045, 0.09 and 0.18 pounds active ingredient per acre (lb ai per A) as the 1X, 2X and 4X rates. In 2008, 2009, 2010 and 2011, halosulfuron rates were 0.031, 0.063, and 0.125 lb ai per acre; the lowest registered rate is 0.031 lb ai per acre.

Of the 137 in-ground or container grown plant genera or species examined, 36 crops exhibited no or minimal transient injury after application at all three rates. Eleven crops exhibited no phytotoxicity at 0.045 lb ai per acre but did have some injury at the higher rates. Twenty four crops exhibited phytotoxicity at even the lowest rate.

Indaziflam Crop Safety

From 2011 through 2019, IR-4 has completed 141 trials evaluating two granular and one liquid formulations of indaziflam for crop safety. The data contained in this report was generated to register the use of indaziflam on and around environmental horticulture plants with over-the-top applications. The rates tested were 0.045, 0.089 and 0.178 pounds active ingredient per acre (lb ai per A) as the 1X, 2X and 4X rates. The indaziflam 0.03%G formulation was applied to 17 plant genera or species, the Marengo G formulation applied to 34 crops, and the Marengo 74SC liquid formulation applied to 17 genera or species. Of these crops, 8 exhibited no or minimal transient injury after application at all three rates including *Aucuba japonica, Berberis sp.*, *Liriope sp.*, *Ophiopogon japonicus*, *Rhododendron sp., Rosa sp*., *Taxus media* and certain *Viburnum* species. The remaining crops evaluated have only

been screened in 1 or two trials or exhibited minimal to significant injury. Further testing is required on many species before a conclusion can be made confirming crop safety.

Iron HEDTA Crop Safety

Fiesta (Iron HEDTA) is a new herbicide currently labeled for post emergence broadleaf weed control on lawns (use on rights of way or non-crop areas), turf, golf courses, parks, playgrounds, cemeteries and athletic fields. Neudorff is interested in adding environmental horticulture crops to the Fiesta label. The IR-4 Project completed 146 crop safety trials on 83 environmental horticulture plant species / genera during 2016 to 2019. In these trials, 7 plant species / genera (*Buxus* sp*., Calamagrostis acutiflora, Carex cherokeensis, Festuca glauca*, *Juniperus* spp., *Muhlenbergia capillaris* and *Taxus x media*) exhibited no or minimal transient injury after application to either dormant or actively growing plants at all 3 rates in at least 3 trials. Six species / genera (*Cotoneaster apiculatus, Heuchera* spp*., Hibiscus* sp., *Lagerstroemia indica, Ophiopogon* sp. and *Teucrium chamaedrys*), where Fiesta was applied to actively growing plants, exhibited no phytotoxicity at 1X but did have some injury at 2X and 4X rates. Twenty species / genera exhibited significant phytotoxicity at even the lowest rate; in ten of these crops, Fiesta was applied to dormant plants.

Isoxaben Crop Safety

Gallery 75DF (isoxaben) was initially registered in 1992 for ornamental horticulture uses. This initial label contained an extensive list of ornamental horticulture crops where Gallery could be used without causing phytotoxicity. It also included a short list of crops where Gallery applications were not recommended. Between 1992 and 2013, IR-4 examined 98 crop species / genera to expand this label to other crops, including several different fern species grown in field containers. Of these, 24 crop species exhibited no or minimal transient injury with 20 already placed on the Gallery label. Eight crops exhibited injury in this research: *Astilbe sp.*, *Athyrium filix-femina, Buddleia davidii, Dendranthema x morifolium*, *Digitalis purpurea*, *Echinacea purpurea, Stachys byzantine*, and *Thymus sp*. A new formulation, Gallery SC, was tested between 2014 and 2019 to determine crop safety on 35 species / genera in 74 trials. Of these, two species, *Chasmanthium latifolium, Juncus effusus, Leymus arenarius, Sorghastrum nutans, Sporobolus heterolepis,* and *Stipa sp.* exhibited no or minimal transient injury; *C. latifolium* is already in the Gallery SC label.

Mono and di potassium salts of phosphorous acid + Hydrogen peroxice Crop Safety

OxiPhos (Mono and di potassium salts of phosphorus acid + hydrogen peroxide) is labeled for managing oomycetes (downy mildew, Phytophthora and Pythium pathogens) and diseases caused by certain bacterial pathogens. While the label does list specific crops, additional screenings were needed to broaden this list. The IR-4 Project completed 23 crop safety trials on 11 environmental horticulture plant species or genera during 2016 to 2019. No injury was observed on azalea and rose; these two crops can be added to the list of crops previously tested for crop safety. For the remaining nine crops, more information is needed either because only 1 or 2 trials were conducted or because consistent results were not achieved across research sites.

Oxalis Efficacy

Nursery growers have had a longstanding battle to control weeds in environmental horticulture crops. Oxalis (*Oxalis* spp.) is one of the most difficult weeds to control in container grown ornamentals. It grows aggressively in containers and can outcompete ornamental crops for water, nutrients, and light. Several chemical tools are available for preemergent control. However, there remains a need for effective control of emerged weed seedlings. At the 2007 Environmental Horticulture Workshop, IR-4 initiated a study to determine whether preemergent herbicides could provide efficacy for oxalis, and other weeds, up to the 2-4 leaf stage. Research was conducted from 2008 through 2019. This report is a brief summary of available data from 27 experiments received through the IR-4 Environmental Horticulture Program. Early postemergence applications of Casoron, Certainty, Dismiss, Gallery, Marengo/Indaziflam, SureGuard, Tower and V-10142 provided significant impact on emerged oxalis (*Oxalis* spp*.)*. These findings benefit growers by identifying select preemergence herbicides which control specific weeds at early emergence stages in container grown ornamental horticulture crops.

Prodiamine Crop Safety

Prodiamine has been registered in the United States for many years for uses in and around ornamental plants in production nurseries and in landscapes. There have been several label amendments expanding the list of ornamental plants where prodiamine formulations can be used. Since 1977, the IR-4 Project has conducted over 568 trials using granular, wettable powder, wettable dry granular and emulsifiable concentrate formulations. The marketplace contains multiple brands of prodiamine with similar formulations. This report is written to support amending any prodiamine label, so prodiamine will be used throughout instead of trade names with the exception of the specific products and formulations tested as referred to in Tables 4 and 5.One hundred thirty-two plant species or genera exhibited no or minimal, transitory phytotoxicity to applications of WDG, WP and EC formulations. Of these, 64 species or genera are not currently on prodiamine WDG labels. It is recommended that 36 of these be placed on these labels along with moving 12 species from the portion of the label excluding use in CA to the portion of the label including use in CA. With additional data demonstrating no or minimal transient phytotoxicity, it is recommended the remaining 25 species also be added. Twenty three species or genera exhibited no phytotoxicity at a 1X rate of the WDG, WP or EC formulations, but at higher rates there was some damage. Since some of the data was generated with EC and wettable powder formulations along with wettable dry granular formulations, it is recommended additional research be conducted on these species. Only 8 species (*Ajuga sp., Carex pennsilvanica, Ilex x meserveae, Limonium sp., Petunia x hybrida, Sedum spurium, Viola tricolor,* and *Zinnia sp.*) demonstrated significant phytotoxicity even at a low label rate. Sixty plant species or genera exhibited no or minimal transitory phytotoxicity to applications of prodiamine G formulations. Of these 11 are not currently listed on prodiamine G labels. It is recommended that these be placed on the labels. Only 2 crops (*Cortaderia* and *Leucanthemum maximum*) exhibited significant damage after prodiamine G applications.

Pydiflumetofen Crop Safety

Pydiflumetofen is a new fungicide being developed by Syngenta for the control of leaf spots (*Septoria, Cercospora, Alternaria, Venturia*), powdery mildew, *Fusarium, Botrytis, Sclerotinia, Corynespora,* and other foliar diseases. The IR-4 Project completed 61 crop safety trials on 22 ornamental horticulture plant species or genera during 2015 to 2019. In these trials, all 22 species or genera exhibited minimal or no injury. Ten genera exhibited minimal or no injury in 3 trials and 12 species or genera exhibited minimal or no injury in the limited number of trials (one or two) for each crop. Syngenta may consider adding these to the label.

Picarbutrazox Crop Safety

Picarbutrazox is a novel fungicide with a new mode of action being developed by Nisso America for the control of oomycete diseases such as *Bremia, Peronospora, Pseudoperonospora, Phytophthora* and *Pythium.* The IR-4 Project completed 27 crop safety trials on 12 environmental horticulture plant species or genera during 2018. In these trials, all 12 species or genera exhibited no or minimal injury. Three species or genera (*Impatiens hawkeri, Impatiens walleriana* and *Rosa* sp.) exhibited no injury in 3 trials, and 9 species or genera exhibited no or minimal injury in the limited number of trials (one or two) for each crop. Nisso America may consider including these to a future label.

Rhizoctonia Efficacy

From 1999 to 2019, numerous products representing 48 active ingredients were evaluated in several greenhouse experiments as soil drench, soil incorporation, foliar or soak application, and in 2 field trials as soil drench, against *Rhizoctonia solani*. Trials were conducted on begonia, chrysanthemum, garden impatiens, petunia, poinsettia, snapdragon, viburnum and zinnia. The relatively new registered products Affirm/Endorse/Veranda O (polyoxin D), Empress Intrinsic (pyraclostrobin), Heritage (azoxystrobin), Medallion (fludioxonil), Mural (azoxystrobin + benzovindiflupyr) and Pageant Intrinsic (p*yraclostrobin + boscalid)* showed excellent efficacy. Although there were insufficient data for definitive conclusions, BAS 703/Orkestra, BAS 750, Broadform, Compass, Disarm, Hurricane, Picatina, Promax, Prostar, Tourney and Trinity generally provided good to excellent efficacy, while Astun, SP2700, and ZeroTol generally provided poor to mediocre efficacy. The biological products Actinovate, Howler, IT-5103,

MBI-110/Stargus, MBI-601, Pvent, RootShield PLUS and SoilGard also provided mediocre to excellent efficacy in limited number of tests. Of the established standards, Terraclor generally provided good efficacy, while 3336 generally provided inconsistent efficacy.

Scale & Mealybug Efficacy

Managing scale and mealybug insects presents unique challenges. Products with contact modes of action must be applied at specific timings in order to reach the most susceptible crawler stages. Products with systemic modes of action may work well for certain species and not others based on application timing and whether the insect feeds within phloem or xylem. In 2003, IR-4 initiated a high priority project to determine efficacy of several insecticides on several scale and mealybug species so data can be obtained to add appropriate species to existing registrations. This research was conducted between 2004 and 2020.This report is a brief summary of available data from 94 experiments received through the IR-4 Environmental Horticulture Program.

Several neonicotinoids (Aloft SC/Celero 16WSG, Flagship 0.22G/25WP, Safari 2G/20SG/Transtect 70WSP, and TriStar 30SG/70WSP), insect growth regulators (Distance and Talus 40SC/70DF), and other products were tested against scales and mealybugs. All products tested generally provided excellent control of elongate hemlock scale, cryptomeria scale, gloomy scale, citrus mealybug and Mexican mealybug, generally mediocre to excellent control of false oleander scale, Fletcher scale, Florida wax scale, magnolia scale, and poor control of armored scale. For other species, efficacy levels varied with the active ingredient and method/timing of application. In single trials, Altus, Talus and Ventigra provided good efficacy on cycad scale, while Altus, Pradia, Sarisa and Talus provided good efficacy on lobate lac scale.

All products tested on citrus mealybug and Mexican mealybug, including Aria, Flagship, Safari, Talus, and TriStar, generally provided good to excellent control of these species. An experiment on Madeira mealybug showed excellent control when TriStar was mixed with Capsil surfactant, and poor control without Capsil. Rycar, Safari and Talus provided good to excellent control of this species, while A16901B provided mediocre control when applied as drench but good when applied as foliar treatment. Pradia and Ventigra also provided excellent control of Madeira mealybug. Phormium mealybug control was good to excellent with all neonicotinoids tested – Flagship, Safari and TriStar. Good to excellent control of Rhizoecus root mealybug was obtained with A16901B, Aria, Kontos, MBI-203, MBI-205 and Safari in single experiments. ISM555 provided good control of crapemyrtle bark scale and Madeira mealybug, while SP3014 provided good control of Madeira mealybug, in single trials.

Seven recently registered products (Altus, Mainspring, Pradia, Rycar, Sarisa, Ventigra and XXpire) looked promising on several species based on their efficacy relative to standards. Further research is needed to obtain additional efficacy data to recommend actions to register or amend labels for these pests.

Spurge Efficacy

Nursery growers have had a longstanding battle to control weeds in environmental horticulture crops. Spurge (*Chamaesyce maculata*), is one of the most difficult weeds to control in container grown ornamentals. It grows aggressively in containers and can outcompete ornamental crops for water, nutrients, and light. Several chemical tools are available for preemergent control. However, there remains a need for effective control of emerged weed seedlings. At the 2007 Environmental Horticulture Workshop, IR-4 initiated a study to determine whether preemergent herbicides could provide efficacy for spurge, and other weeds, up to the 2-4 leaf stage. Research was conducted from 2008 through 2019. This report is a brief summary of available data from 18 experiments received through the IR-4 Environmental Horticulture Program. Early postemergence applications of Casoron, Certainty, Gallery, Marengo/Indaziflam, Pendulum, SP 1770, Tower and V-10142 provided significant control of emerged spurge. These findings benefit growers by identifying select preemergence herbicides which control specific weeds at early emergence stages in container grown ornamental horticulture crops.

Sulfentrazone Crop Safety

Since 1996 IR-4 has completed 259 trials with products containing sulfentrazone (Sulfentrazone 0.2G and Dismiss 4F) on 111 crops. The data contained in this report was generated to register uses of sulfentrazone on and around environmental horticulture plants with over-the-top applications. The sulfentrazone rates in the testing programs were 0.125, 0.25 and 0.5 pounds active ingredient per acre (lb ai per A) as the 1X, 2X and 4X rates. Sulfentrazone 0.2G had been applied to 54 plant genera or species. Of these, 12 exhibited no or minimal transient injury after application at all three rates. One crop exhibited no phytotoxicity at 0.125 and 0.25 lb ai per acre but did have some injury at 0.5 lb ai per acre. Only 3 crops (*Canna sp.*, *Echinacea purpurea*, and *Hosta sp*.) exhibited phytotoxicity at even the lowest rate. Dismiss 4F has been applied to 65 crops since 1996. Of these only 6 (*Buxus sp., Ilex vomitoria 'nana', Juniperus horizontalis, Rosa sp., Taxus sp.*, and *Thuja sp.*) exhibited no damage with over the top applications at all tested rates. Seven crops had minimal, transitory damage at the lower rates but some phytotoxicity at the 4X rate and 15 crops exhibited damage at all tested rates.

Thielaviopsis Efficacy

From 2003 to 2018, numerous products representing 31 active ingredients were evaluated in greenhouse trials as soil drench against *Thielaviopsis basicola* causing black root rot on ornamentals. Although there were insufficient data for definitive conclusions, two new experimentals (BAS 750 - mefentrifluconazole) and A20808C showed promising efficacy comparable to the standards. Several products that are not yet labeled for *Thielaviopsis basicola* also showed promising efficacy in single trials. These include Empress Intrinsic (pyraclostrobin), Endorse/Veranda O (polyoxin D), *Mural (a*zoxystrobin + benzovindiflupyr), Picatina Flora (Pydiflumetofen + fludioxonil*),* Stargus (*Bacillus amyloliquefaciens* strain F727*).* Tourney (metconazole) and Vital (potassium phosphite). The established standards 3336 and Terraguard generally provided excellent efficacy.

Thrips Efficacy

For the last 14 years, the IR-4 Environmental Horticulture Workshop has ranked developing efficacy data on new products to manage thrips as a High Priority Project either nationally or regionally. Thrips remain an important threat for several reasons: 1) the damage thrips cause to environmental horticulture plants, decreasing the value of the infested crops; 2) the tospoviruses (tomato spotted wilt, impatiens necrotic ringspot) they can vector; 3) the newly arrived invasive species which impact at least 250 different environmental horticulture species; and 4) growers lack the ability to rotate among 3 to 4 different modes of actions to effectively manage resistance development in the thrips populations they must control to maintain economic viability. From 2005 through 2019, 89 products representing 59 different active ingredients were tested for thrips management. These products represented both biological and chemical tools. Some products were already registered, but more data were needed particularly with the newly invasive thrips species or they were considered standards to measure the level of efficacy achieved with other materials. Other products were in development but have not yet been registered with the EPA. The five thrips species tested in the IR-4 program were Chilli Thrips (*Scirtothrips dorsalis*), Gladiolus Thrips (*Thrips simplex*), Privet Thrips (*Dendothrips ornatus*), Weeping Fig Thrips (*Gynaikothrips uzeli*), and Western Flower Thrips (*Frankliniella occidentalis*).

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