



[Environment Horticulture Program Research Summaries](#)

IR-4 Environmental Horticulture Program Prodiamine + Isoxaben Crop Safety

**Authors: Roger Batts and Cristi L. Palmer
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**Acknowledgements
Susan Bierbrunner
Ely Vea**

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Abstract

Prodiamine + Isoxaben (Gemini G) is a herbicide combination developed by Everris dba ICL Specialty Fertilizers for pre-emergent control of grasses and broadleaf weeds on environmental horticulture crops. The IR-4 Project completed 65 crop safety trials on 23 environmental horticulture plant species or genera between 2017 and 2022. In these trials, four species (*Campanula sp.*, *Nepeta x fassiana*, *Quercus virginiana*, *Rosa sp.*) exhibited no injury after over-the-top applications in a minimum of 3 trials; this species can be added to a list of tolerant plants in the new label for this product. Three species (*Phlox paniculata*, *Sedum acre*, *Sedum rupestre*) exhibited damage at the 1X rate sufficient to recommend growers not utilize Gemini G as an over-the-top treatment for pre-emergent weed control.

Introduction

Prodiamine + isoxaben (Gemini G) is a herbicide combination developed by Everris dba ICL Specialty Fertilizers for pre-emergent control of grasses and broadleaf weeds on environmental horticulture crops. The IR-4 Project completed 65 crop safety trials on 25 environmental horticulture plant species or genera between 2017 and 2022.

Materials and Methods

Gemini G (prodiamine + isoxaben) was applied over-the-top twice at 6 weeks intervals. The application rates were 200, 400 and 800 lb product/A. A minimum of four plants per three blocks or ten plants per completely randomized design were required with many researchers exceeding this minimum. Phytotoxicity was recorded on a scale of 0 to 10 (0 = no phytotoxicity; 10 = complete kill) at 1, 2, and 4 weeks after initial application. To view the more detailed materials and methods in the protocol 17-010, 18-012, 21-013, and 22-017. Please see <https://www.ir4project.org/ehc/ehc-registration-support-research/env-hort-researcher-resources/#Protocols> to view and download protocols.

Gemini G was supplied to researchers (See list of researchers in Appendix 1) by Everris dba ICL Specialty Fertilizers.

Results and Summary

Phytotoxicity

Based on the type and nature of injury seen with the protocol treatments, tested plant species were placed into four categories: 1) no significant phytotoxicity or growth differences from the untreated check or any injury was transitory, 2) no or minimal transitory injury seen at the 1X rate, but the 2X and/or 4X rates did cause significant phytotoxicity, 3) significant injury at the 1X rate sufficient to recommend growers not utilize Gemini G, and 4) more data are needed to make informed recommendations.

Gemini G exhibited no or minimal negative impact on four species with over-the-top applications (Table 1). Some minimal injury may be acceptable for growers, if applications are made several weeks to months in advance of crop sale particularly for woody ornamental crops. Three species tested exhibited damage at the 1X rate sufficient to recommend growers not utilize Gemini G as an over-the-top treatment for pre-emergent weed control (Table 3). For 18 genera / species, more information is needed either because only 1 or 2 trials were conducted or because consistent results were not achieved across research sites (Table 4, Table 5).

Please see Table 6 for a list of individual trial summaries for Gemini G.

Table 1. List of Gemini G treated crops with no or minimal transitory injury.

<i>Campanula sp.</i>	<i>Quercus virginiana</i>
<i>Nepeta x fassiana</i>	<i>Rosa sp.</i>

Table 2. List of Gemini G treated crops with no injury at 1X but significant injury at 2X or 4X.

None

Table 3. List of Gemini G treated crops with significant injury at 1X.

<i>Phlox paniculata</i>	<i>Sedum rupestre</i>
<i>Sedum acre</i>	

Table 4. List of Gemini G treated crops where more information is needed.

<i>Acer rubrum</i>	<i>Hemerocallis sp.</i>	<i>Tagetes erecta</i>
<i>Echinacea sp.</i>	<i>Hydrangea macrophylla</i> ¹	

Table 5. List of Gemini G treated crops with less than 3 trials.

<i>Allamanda cathartica</i> ¹	<i>Hydrangea arborescens</i>	<i>Sporobolus heterolepis</i> ¹
<i>Calamagrostis acutiflora</i>	<i>Hydrangea quercifolia</i> ¹	<i>Pelargonium x domesticum</i> ¹
<i>Digitalis purpurea</i>	<i>Juncus effusus</i> ¹	<i>Sedum hybridum</i>
<i>Digitalis sp.</i>	<i>Muhlenbergia capillaris</i> ¹	
<i>Euonymus alatus</i>	<i>Paeonia lactiflora</i>	

¹For these plants, the one or two trials presented here indicate no phytotoxicity or slight, transient injury

²Listed on label as one of crops where Gemini should not be used.

Table 6. Detailed Summary of Crop Safety Testing with Gemini G (Prodiamine + Isoxaben).

Notes: Table entries are sorted by crop Latin name. Only those trials with research reports received by 11/1/2022 are listed below.

PR#	Crop	Production Site	Researcher	State	Year	Application Type	Results
32929	Maple, Red (<i>Acer rubrum</i>) Red Maple	Field Container	Beste	MD	2017	Over the top	Unacceptable injury or death with 200, 400 and 800 lb per acre within a month after application.
32929	Maple, Red (<i>Acer rubrum</i>)	Field Container	Marble	FL	2017	Over the top	No significant injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32929	Maple, Red (<i>Acer rubrum</i>)	Field Container	Mathers	OH	2018	Over the top	No injury and growth reduction with 200, 400 and 800 lb per acre applied twice.
32929	Maple, Red (<i>Acer rubrum</i>)	Field Container	Senesac	NY	2017	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32913	Allamanda (<i>Allamanda</i> sp.) <i>A. cathartica</i> 'Golden Butterfly'	Field Container	Marble	FL	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
34960	Feather Reed Grass (<i>Calamagrostis acutiflora</i>)	Field Container	Derr	VA	2022	Broadcast	Very slight injury with 1.3, 2.6, and 5.2 lb ai per acre.
32925	Bellflower (<i>Campanula</i> sp.)	Field Container	Larson	WA	2021	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32925	Bellflower (<i>Campanula</i> sp.) <i>C. posharkyana</i> , 'Blue Waterfall'	Field Container	Reding	OH	2017	Over the top	No injury with 200, 400 and 800 lb per acre after 1st applic, moderate after 2nd applic with complete recovery; no growth reduction; all plants marketable.
32925	Bellflower (<i>Campanula</i> sp.) <i>C. portenschlagiana</i> 'Birch Hybrid'	Field Container	Senesac	NY	2017	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32924	Foxglove (<i>Digitalis</i> sp.)	Field Container	Larson	WA	2021	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32924	Foxglove (<i>Digitalis</i> sp.) <i>D. purpurea</i> 'Candy Mountain'	Field Container	Reding	OH	2017	Over the top	No injury with 200, 400 and 800 lb per acre after 1st applic, unacceptable with 2X and 4X; 2X and 4X plants unmarketable.
32924	Foxglove (<i>Digitalis</i> sp.) 'Dalmatian Purple'	Field Container	Senesac	NY	2017	Over the top	Moderate injury with 200 and 400, severe with 800 lb per acre applied twice
32923	Purple Coneflower (<i>Echinacea</i> sp.) 'Cheyenne Spirit'	Field Container	Derr	VA	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32923	Purple Coneflower (<i>Echinacea</i> sp.) <i>E. purpurea</i> 'Hot Summer'	Field Container	Marble	FL	2017	Over the top	No injury or growth reduction with 200 and 400, minor injury and significant growth reduction with 800 lb per acre, applied twice.
32923	Purple Coneflower (<i>Echinacea</i> sp.)	Field Container	Mathers	OH	2017	Over the top	Minor to moderate initial injury with complete recovery at end of trial with 200, 400 and 800 lb per acre applied twice; no growth reduction.
32922	Burning Bush (<i>Euonymus alatus</i>)	Field Container	Larson	WA	2021	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32922	Burning Bush (<i>Euonymus alatus</i>) 'Compacta'	Field Container	Senesac	NY	2017	Over the top	Minor injury with 200, 400 and 800 lb per acre applied twice.

PR#	Crop	Production Site	Researcher	State	Year	Application Type	Results
32921	Daylily (Hemerocallis sp.) 'Stella d' Oro'	Field Container	Beste	MD	2017	Over the top	Slight initial injury with quick recovery at 200, 400 and 800 lb per acre applied twice; no growth reduction; all treated plants marketable.
32921	Daylily (Hemerocallis sp.) 'Stella d'Oro'	Field Container	Derr	VA	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32921	Daylily (Hemerocallis sp.) Hemerocallis x 'Monie' Starburst R Susie	Field Container	Nackley	OR	2017	Over the top	Minor to moderate injury increasing with rates (200, 400 and 800 lb per acre) applied twice; no growth reduction.
32921	Daylily (Hemerocallis sp.) 'Happy Returns'	Field Container	Reding	OH	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice; all plants marketable.
32911	Bigleaf Hydrangea (Hydrangea macrophylla) 'Nikko Blue'	Field Container	Beste	MD	2017	Over the top	Moderate injury at 200, 400 and 800 lb per acre applied twice; all treated plants commercially unmarketable.
32911	Bigleaf Hydrangea (Hydrangea macrophylla)	Field Container	Nackley	OR	2017	Over the top	Minor to moderate injury increasing with rates (200, 400 and 800 lb per acre) after 2nd applic; no significant growth reduction.
32911	Bigleaf Hydrangea (Hydrangea macrophylla) 'Endless Summer'	Field Container	Neal	NC	2017	Over the top	Unacceptable injury (chlorotic and necrotic buds) and reduction of canopy volume with 200, 400 and 800 lb per acre applied twice.
32911	Bigleaf Hydrangea (Hydrangea macrophylla) 'Let's dance Rythmic Blue'	Field Container	Reding	OH	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice; all plants marketable.
32911	Bigleaf Hydrangea (Hydrangea macrophylla) 'Paraplu'	Field Container	Senesac	NY	2017	Over the top	Minor injury with 200, moderate with 400, and severe with 800 lb per acre applied twice.
32912	Hydrangea (Hydrangea sp.) H. macrophyll 'Dooley'	Field Container	Derr	VA	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32912	Hydrangea (Hydrangea sp.) H. macrophylla 'Nikko Blue'	Field Container	Gilliam	AL	2017	Over the top	No significant injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32912	Hydrangea (Hydrangea sp.) H. quercifolia	Field Container	Marble	FL	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32912	Hydrangea (Hydrangea sp.) H. quercifolia	Field Container	Mathers	OH	2017	Over the top	Acceptable injury with 200 and 400, unacceptable with 800 lb per acre applied twice; minor growth reduction with 4X.
32912	Hydrangea (Hydrangea sp.) H. arborescens, 'Invincibelle Spirit II'	Field Container	Reding	OH	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice; all plants marketable.
34963	Common Rush (Juncus effusus)	Field Container	Derr	VA	2022	Over the top	Very slight transient injury with 1.3, 2.6 and 5.2 lb ai per acre.
34964	Muhly, Hairyaw (Muhlenbergia capillaris)	Field Container	Derr	VA	2022	Over the top	Very minor injury with 1.3, 2.6, and 5.2 lb ai per acre.
32920	Nepeta (Nepeta x faassenii) 'Walker's Low'	Field Container	Beste	MD	2017	Over the top	No injury with 200, 400 and 800 lb per acre applied twice; minor growth reduction with 4X; all plants marketable.
32920	Nepeta (Nepeta x faassenii)	Field Container	Larson	WA	2021	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.

PR#	Crop	Production Site	Researcher	State	Year	Application Type	Results
32920	Nepeta (Nepeta x faassenii)	Field Container	Senesac	NY	2017	Over the top	Minor injury with 200 and 400, moderate with 800 lb per acre applied twice.
32919	Peony, Common Garden (Paeonia lactiflora)	Field Container	Larson	WA	2021	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32919	Peony, Common Garden (Paeonia lactiflora) 'Sarah Bernhardt'	Field Container	Reding	OH	2021	Over the top	Minor injury to death increasing with rate. Growth stunted at all rates (200, 400 and 800 lbs/acre)
32927	Regal Geranium (Pelargonium x domesticum) 'Regal Candy - red'	Field Container	Reding	OH	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice; all plants marketable.
32927	Regal Geranium (Pelargonium x domesticum) 'Salmon'	Field Container	Senesac	NY	2019	Over the top	No injury or stunting with 200, 400 and 800 lb per acre applied twice.
32918	Phlox, Fall (Phlox paniculata) 'Bright Eyes'	Field Container	Doohan	OH	2018	Over the top	No significant injury with 200, severe with 400 and 800, lb per acre applied twice; growth reduction at 2X and 4X.
32918	Phlox, Fall (Phlox paniculata) 'Festival'	Field Container	Fraelich	GA	2022	Over the top	Minor but transient leaf injury with 100 and 200 lb per acre with no significant impact on growth, but moderate injury and a significant growth reduction with 400 lb per acre.
32918	Phlox, Fall (Phlox paniculata)	Field Container	Mathers	OH	2017	Over the top	Acceptable injury with 200, unacceptable with 400 and 800 lb per acre applied twice; moderate growth reduction with 2X and 4X.
32918	Phlox, Fall (Phlox paniculata) 'Cotton Candy'	Field Container	Nackley	OR	2017	Over the top	Moderate to severe injury increasing with rates (200, 400 and 800 lb per acre) applied twice; moderate growth reduction with 4X.
32918	Phlox, Fall (Phlox paniculata) 'Party Punch'	Field Container	Reding	OH	2017	Over the top	Unacceptable injury and growth reduction with 200, 400 and 800 lb per acre applied twice; all plants unmarketable.
32918	Phlox, Fall (Phlox paniculata) 'Fashion Early Flamingo'	Field Container	Senesac	NY	2022	Over the top	Severe injury with all rates (2.5, 5.0, 10.0 lb ai per acre).
32928	Oak, Southern Live (Quercus virginiana)	Field Container	Gilliam	AL	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32928	Oak, Southern Live (Quercus virginiana)	Field Container	Marble	FL	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice.
32928	Oak, Southern Live (Quercus virginiana)	Field Container	Senesac	NY	2017	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32917	Rose (Rosa sp.) 'BaMir' Easy Elegance® Kashmir Rose'	Field Container	Nackley	OR	2017	Over the top	Minor injury with complete recovery with 200, 400 and 800 lb per acre applied twice; no significant growth reduction.
32917	Rose (Rosa sp.) Red Knockout Rose	Field Container	Neal	NC	2017	Over the top	No injury with 200, 400 and 800 lb per acre after 1st applic.; 18-25% initial injury with complete recovery after 2nd applic. No growth reduction.
32917	Rose (Rosa sp.) Rosa x 'Horcoherent' (OSO Easy Peachy Cream)	Field Container	Senesac	NY	2017	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.

PR#	Crop	Production Site	Researcher	State	Year	Application Type	Results
32914	Stonecrop, Moss (Sedum acre)	Field Container	Marble	FL	2019	Over the top	No injury or significant growth reduction with 200, 400 and 800 lb per acre applied twice.
32914	Stonecrop, Moss (Sedum acre) 'Aurea'	Field Container	Neal	NC	2018	Over the top	Severe injury and growth reduction with 200, 400 and 800 lb per acre applied twice.
32914	Stonecrop, Moss (Sedum acre) 'Goldmoss'	Field Container	Reding	OH	2021	Over the top	Severe injury to mortality increasing with rate. Growth stunted and flower production prevented at all application rates (200,400 and 800 lbs/acre)
32915	Sedum Hybrids (Sedum hybridum)	Field Container	Larson	WA	2021	Over the top	No injury with 200, 400 and 800 lb per acre applied twice.
32915	Sedum Hybrids (Sedum hybridum) S. hybridum	Field Container	Senesac	NY	2019	Over the top	Minor injury with 200, moderate with 400 and 800 lb per acre applied twice; no growth reduction.
32916	Stonecrop, Jenny's (Sedum rupestre) S. rupestre 'Blue Spruce' and S. album 'Red Ice'	Field Container	Aulakh	CT	2018	Over the top	Two trials. No injury or growth reduction with 200, 400 and 800 lb per acre applied twice on 2 species - Sedum rupestre and Sedum album.
32916	Stonecrop, Jenny's (Sedum rupestre)	Field Container	Derr	VA	2018	Over the top	Good to excellent control increasing with rates (200, 400 and 800 lb per acre) applied twice. Moderate to severe crop shoot weight reduction.
32916	Stonecrop, Jenny's (Sedum rupestre)	Field Container	Marble	FL	2019	Over the top	Moderate to severe injury and growth reduction increasing with rates (200, 400 and 800 lb per acre) applied twice.
32916	Stonecrop, Jenny's (Sedum rupestre) 'Angelina'	Field Container	Neal	NC	2018	Over the top	Severe injury and growth reduction with 200, 400 and 800 lb per acre applied twice.
34965	Prairie Dropseed (Sporobolus heterolepis)	Field Container	Derr	VA	2022	Broadcast	No to very slight injury with 1.3, 2.6, and 5.2 lb ai per acre.
32926	Marigold, African (Tagetes erecta)	Field Container	Marble	FL	2017	Over the top	No to minor injury with 200, 400 and 800 lb per acre applied twice.
32926	Marigold, African (Tagetes erecta) 'Inca Yellow'	Field Container	Reding	OH	2017	Over the top	No injury or growth reduction with 200, 400 and 800 lb per acre applied twice; all plants marketable.
32926	Marigold, African (Tagetes erecta) 'Taisha Gold'	Field Container	Senesac	NY	2017	Over the top	Moderate injury with 200 and 400, severe with 800 lb per acre applied twice.

Label Suggestions

We recommend that the following crop, which exhibited no injury in these experiments, be added to the future Gemini G label for broadcast applications.

Campanula sp.
Nepeta x fassiana
Quercus virginiana
Rosa sp.

We also suggest that the one plant species exhibiting significant injury with over-the-top applications be added to list of sensitive ornamental species.

Phlox paniculata

Appendix 1: Contributing Researchers

Dr. Jatinder S Aulakh	Connecticut Agricultural Experiment Station Valley Laboratory 143 Cook Hill Road, P.O. Box 228 Windsor, CT
Dr. Ed Beste (<i>retired</i>)	University of Maryland LESREC – Salisbury Facility 27662 Nanticoke Road Salisbury, MD 21801
Dr. Jeffrey Derr	Hampton Roads Ag. Exp. Station 1444 Diamond Springs Road, Virginia Beach, VA 23455
Dr. Doug Doohan	Ohio State University OARDC Weed Lab 1680 Madison Avenue Wooster, OH 44691
Mr. Ben Fraelich	USDA-ARS 2316 Rainwater Rd. P.O. Box 748 Tifton GA 31793
Dr. Charles Gilliam (<i>retired</i>)	Auburn University Department of Horticulture 101 Funchess Hall Auburn, AL 36849
Mr. Duane Larson	USDA-ARS Temperate Tree Fruit & Vegetable Research Unit 5230 Konnawac Pass Road Wapato, WA, 98951
Dr. Chris Marble	University of Florida Mid-Florida Research and Education Center 2725 S. Binion Rd. Apopka, FL 32703
Dr. Hannah Mathers	Mathers Environmental Science Services, LLC Gahanna, OH 43230

Dr. Lloyd Nackley

Oregon State University
North Willamette Exp Sta
15210 NE Miley Rd
Aurora, OR 97002-9543

Dr. Joe Neal

North Carolina State University
Department of Horticultural Science
262 Kilgore Hall
Box 7609, NCSU
Raleigh, NC 27694-7609

Dr. Michael Reding

USDA-ARS
Application Technology Research Rm 2269
1680 Madison Ave.
Wooster, OH, 22691

Dr. Andy Senesac
(*retired*)

Long Island Horticultural Research Laboratory
39 Sound Avenue
Riverhead, NY 11901