



[Environment Horticulture Program Research Summaries](#)

IR-4 Environmental Horticulture Program Isoxaben + Dithiopyr Crop Safety

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**Acknowledgements
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Abstract

Fortress (isoxaben + dithiopyr) was registered in 2018 for environmental horticulture crop uses. Between 2018 and 2022, IR-4 examined 27 crop species / genera to expand this label to other crops. Of these, 7 crop species exhibited no or transient injury. One species exhibited significant injury from isoxaben + dithiopyr at the 1X rate (*Digitalis grandiflora*).

Introduction

Fortress (isoxaben + dithiopyr) was recently registered for environmental horticulture crop uses. Between 2018 and 2022, IR-4 examined 27 crop species / genera to expand this label to other crops.

Materials and Methods

Fortress at rates of 150, 300 and 600 lb per acre was applied over-the-top twice at 6 weeks intervals, with the first application within 7 days after potting. 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 each application. For IR-4 testing, the following protocols were used: 18-012, 19-012, 20-013 and 22-017. For more detailed materials and methods, please visit <https://www.ir4project.org/ehc/ehc-registration-support-research/env-hort-researcher-resources/#Protocols> to view and download these protocols.

Fortress was supplied to researchers (See list of researchers in Appendix 1) by OHP.

Results and Summary

Phytotoxicity

Based on the type and nature of injury seen with isoxaben + dithiopyr applications in the research conducted between 2018 and 2022, 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 sufficient to recommend growers not utilize this product, and 4) more data are needed to make informed recommendations.

In testing from 2018 and 2022, Fortress exhibited no or minimal negative impact on 8 plant species (Table 1). In this report no crop species was found to exhibit little or no injury at the 150 lb per acre rate, and with significant phytotoxicity at the 300 and 600 lb per acre rates (Tables 2). There was one crop species in the testing that exhibited damage sufficient to recommend growers not utilize Fortress as an over-the-top treatment for postemergent weed control (Table 3).

IR-4 has not generated sufficient information to categorize crop response to Fortress applications on 17 species / genera (Tables 4 and 5). However, no injury was observed on several of these species / genera. Seven of these 17 have already been placed on the label based upon other research.

Please see Table 6 for a list of research and the summary of the results received for research conducted with Fortress from 2018-2022.

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

<i>Andropogon gerardii</i>	<i>Hydrangea paniculata</i> ²
<i>Calamagrostis acutiflora</i>	<i>Hydrangea quercifolia</i> ²
<i>Chrysanthemum/Dendranthema sp.</i> ^{1,3}	<i>Muhlenbergia capillaris</i> ³
<i>Hydrangea macrophylla</i> ²	<i>Nassella tenuissima</i> ³

¹ Already registered

² Current label prohibits use

³ No significant injury in any of at least 3 trials

Table 2. List of Fortress treated crops with no or minimal transitory injury seen at the 1X rate, but significant injury at 2X or 4X.

None

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

Digitalis grandiflora
Digitalis purpurea

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

Achillea millefolium^{1,2}

Achillea sp.^{1, 2}

*Chrysanthemum x rubellum*²

Coreopsis sp.^{1,2}

Dianthus gratianopolitanus^{1,2}

Juncus effusa

Liriope muscari^{1, 2}

¹ Already registered

² No injury in 1 or 2 trials conducted.

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

Andropogon virginicus

Duranta erecta

*Eragrostis curvula*²

*Festuca cinerea*²

Pennisetum setaceum^{1, 2}

Perovskia atriplicifolia^{1,2}

*Phlox stolonifera*²

*Salvia sp.*²

*Salvia sylvestris*²

Sporobolus heterolepis

¹ Already registered

² No injury in 1 or 2 trials conducted.

Table 6. Detailed Summary of Crop Safety Testing with Fortress.

Notes: Table entries are sorted by crop Latin name. Only those reports received by 1/20/2023 are included.

PR#	Product	Crop	Production Site	Researcher	State	Year	Application Type	Results
33649	Fortress (OHP1701B) (isoxaben + dithiopyr)	Yarrow (Achillea sp.) A. millefolium 'New Vintage Rose'	Field Container	Mathers	OH	2019	Over the top	Minor injury with 1.125, moderate with 2.25 and 4.5 lb ai per acre applied twice; moderate growth reduction at 4X.
33649	Fortress (OHP1701B) (isoxaben + dithiopyr)	Yarrow (Achillea sp.)	Field Container	Seefeldt	WA	2020	Over the top	No injury with 1.125, 2.225 or 4.5 lb ai per acre.
33649	Fortress (OHP1701B) (isoxaben + dithiopyr)	Yarrow (Achillea sp.) 'Desert Eve Deep Rose'	Field Container	Witcher	TN	2019	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
34942	Fortress (OHP1701B) (isoxaben + dithiopyr)	Big Blue Stem (Andropogon gerardii)	Field Container	Moretti	OR	2022	Over the top	Minor to no injury from two applications at 150, 300 or 600 lb/a. Plant volume not different from nontreated, regardless of rate.
34942	Fortress (OHP1701B) (isoxaben + dithiopyr)	Big Blue Stem (Andropogon gerardii)	Field Container	Neal	NC	2022	Over the top	No injury at a single application at 2.5, 5.0 or 10 lb ai per acre, but moderate injury was observed after the second application at all rates.
34942	Fortress (OHP1701B) (isoxaben + dithiopyr)	Big Blue Stem (Andropogon gerardii)	Field Container	Witcher	TN	2022	Over the top	No injury or plant growth reductions from two applications at 150, 300 or 600 lb/a.
34943	Fortress (OHP1701B) (isoxaben + dithiopyr)	Broom Sedge Bluestem (Andropogon virginicus)	Field Container	Neal	NC	2022	Over the top	No injury with 2.5 lb ai per acre; after second applications of 5.0 and 10.0 lb ai per acre, moderate lodging was observed.
34944	Fortress (OHP1701B) (isoxaben + dithiopyr)	Feather Reed Grass (Calamagrostis acutiflora)	Field Container	Derr	VA	2022	Broadcast	Very slight injury with 1.125, 2.25, and 4.5 lb ai per acre.
34944	Fortress (OHP1701B) (isoxaben + dithiopyr)	Feather Reed Grass (Calamagrostis acutiflora) 'Karl Foerster'	Field Container	Moretti	OR	2022	Over the top	Little to no injury from two applications at 150, 300 or 600 lb/a. Plant volume not different from nontreated, regardless of rate.
34944	Fortress (OHP1701B) (isoxaben + dithiopyr)	Feather Reed Grass (Calamagrostis acutiflora)	Field Container	Witcher	TN	2022	Over the top	No injury or plant growth reductions from two applications at 150, 300 or 600 lb/a.
33454	Fortress (OHP1701B) (isoxaben + dithiopyr)	Chrysanthemum, Garden (Chrysanthemum/Dendranthema sp.)	Field Container	Seefeldt	WA	2019	Over the top	No injury or growth reduction with 1.12, 2.25 and 4.5 lb ai per acre applied twice.
33454	Fortress (OHP1701B) (isoxaben + dithiopyr)	Chrysanthemum, Garden (Chrysanthemum/Dendranthema sp.) C. x rubellum 'Clara Curtis'	Field Container	Senesac	NY	2019	Over the top	No injury or stunting with 150, 300 and 600 lb per acre applied twice.

33454	Fortress (OHP1701B) (isoxaben + dithiopyr)	Chrysanthemum, Garden (Chrysanthemum/Dendranthema sp.) 'Fancy Ursula Orange'	Field Container	Witcher	TN	2019	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
33449	Fortress (OHP1701B) (isoxaben + dithiopyr)	Tickseed (Coreopsis sp.) 'Nana'	Field Container	Marble	FL	2020	Over the top	Minor transient injury after first application (150, 300, 600 lb per acre) but with recurrence after second application.
33449	Fortress (OHP1701B) (isoxaben + dithiopyr)	Tickseed (Coreopsis sp.) 'Ladybird'	Field Container	Mathers	OH	2019	Over the top	Minor, acceptable injury and growth reduction with 1.125, 2.25 and 4.5 lb ai per acre applied twice.
33449	Fortress (OHP1701B) (isoxaben + dithiopyr)	Tickseed (Coreopsis sp.) 'Jethro Tull'	Field Container	Witcher	TN	2019	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
33648	Fortress (OHP1701B) (isoxaben + dithiopyr)	Cheddar Pink (Dianthus gratianopolitanus) 'Georgia Peach Pie'	Field Container	Klett	CO	2020	Over the top	No injury or significant growth reduction, and no effect on flower production or bloom time, with 150, 300 and 600 lb per acre applied twice.
33648	Fortress (OHP1701B) (isoxaben + dithiopyr)	Cheddar Pink (Dianthus gratianopolitanus) 'Vivid Cherry Charm'	Field Container	Mathers	OH	2021	Over the top	Minor to severe injury 4WAT for first application at 150, 300 and 600 lb per acre (1.125, 2.25 and 4.5 lb ai per acre); second treatment, six weeks later, caused plant death at highest rate.
33648	Fortress (OHP1701B) (isoxaben + dithiopyr)	Cheddar Pink (Dianthus gratianopolitanus)	Field Container	Seefeldt	WA	2020	Over the top	No injury with 1.125, 2.225 or 4.5 lb ai per acre.
33455	Fortress (OHP1701B) (isoxaben + dithiopyr)	Foxglove, Yellow (Digitalis grandiflora) D. purpurea 'Pam's Choice'	Field Container	Mathers	OH	2019	Over the top	Severe injury with 1.125, 2.25 and 4.5 lb ai per acre applied once.
33455	Fortress (OHP1701B) (isoxaben + dithiopyr)	Foxglove, Yellow (Digitalis grandiflora)	Field Container	Seefeldt	WA	2020	Over the top	No injury with 1.125, 2.225 or 4.5 lb ai per acre.
33455	Fortress (OHP1701B) (isoxaben + dithiopyr)	Foxglove, Yellow (Digitalis grandiflora)	Field Container	Senesac	NY	2019	Over the top	Severe injury with 150, 300 and 600 lb per acre applied twice.
34884	Fortress (OHP1701B) (isoxaben + dithiopyr)	Golden Dewdrops (Duranta erecta)	Field Container	Moretti	OR	2022	Over the top	Minor to no injury from two applications at 150, 300 or 600 lb/a. Plant volume not different from nontreated, regardless of rate.
34945	Fortress (OHP1701B) (isoxaben + dithiopyr)	Weeping Lovegrass (Eragrostis curvula)	Field Container	Witcher	TN	2022	Over the top	No injury or plant growth reductions from two applications at 150, 300 or 600 lb/a.
33460	Fortress (OHP1701B) (isoxaben + dithiopyr)	Blue Fescue (Festuca cinerea) Festuca glauca	Field Container	Koivunen	CA	2020	Over the top	No injury and significant growth reduction with 150, 300 and 600 lb per acre applied twice.
33645	Fortress (OHP1701B) (isoxaben + dithiopyr)	Bigleaf Hydrangea (Hydrangea macrophylla) 'Lets Dance Rave'	Field Container	Derr	VA	2020	Over the top	No to minor injury and growth reduction with 150, 300 and 600 lb per acre applied twice.
33645	Fortress (OHP1701B) (isoxaben + dithiopyr)	Bigleaf Hydrangea (Hydrangea macrophylla) 'Nikko Blue'	Field Container	Fraelich	GA	2020	Over the top	Slight injury (leaf curling) and stunting at 150 and 300, moderate at 600 lb per acre applied twice.

33645	Fortress (OHP1701B) (isoxaben + dithiopyr)	Bigleaf Hydrangea (<i>Hydrangea macrophylla</i>)	Field Container	Nackley	OR	2019	Over the top	No significant injury with 150, 300 and 600 lb per acre applied twice.
33645	Fortress (OHP1701B) (isoxaben + dithiopyr)	Bigleaf Hydrangea (<i>Hydrangea macrophylla</i>) 'Paraplu'	Field Container	Senesac	NY	2019	Over the top	No injury with 150, 300 and 600 lb per acre applied twice.
33646	Fortress (OHP1701B) (isoxaben + dithiopyr)	Panicle Hydrangea (<i>Hydrangea paniculata</i>) 'Fire Light'	Field Container	Derr	VA	2020	Over the top	No to minor injury and growth reduction with 150, 300 and 600 lb per acre applied twice.
33646	Fortress (OHP1701B) (isoxaben + dithiopyr)	Panicle Hydrangea (<i>Hydrangea paniculata</i>) 'Pinky Winky'	Field Container	Mathers	OH	2019	Over the top	Moderate initial injury, with complete recovery, with 1.125, 2.25 and 4.5 lb ai per acre applied twice; no significant growth reduction .
33646	Fortress (OHP1701B) (isoxaben + dithiopyr)	Panicle Hydrangea (<i>Hydrangea paniculata</i>)	Field Container	Nackley	OR	2019	Over the top	No significant injury with 150, 300 and 600 lb per acre applied twice.
33647	Fortress (OHP1701B) (isoxaben + dithiopyr)	Hydrangea, Oakleaf (<i>Hydrangea quercifolia</i>)	Field Container	Derr	VA	2020	Over the top	No significant injury and growth reduction with 150, 300 and 600 lb per acre applied twice.
33647	Fortress (OHP1701B) (isoxaben + dithiopyr)	Hydrangea, Oakleaf (<i>Hydrangea quercifolia</i>) Jetstream'	Field Container	Mathers	OH	2019	Over the top	Minor, acceptable injury with 1.125, 2.25 and 4.5 lb ai per acre applied twice; moderate growth reduction at 4X.
33647	Fortress (OHP1701B) (isoxaben + dithiopyr)	Hydrangea, Oakleaf (<i>Hydrangea quercifolia</i>)	Field Container	Nackley	OR	2019	Over the top	No significant injury with 150, 300 and 600 lb per acre applied twice.
34947	Fortress (OHP1701B) (isoxaben + dithiopyr)	Common Rush (<i>Juncus effusus</i>)	Field Container	Derr	VA	2022	Over the top	No significant injury with 1.125 lb ai per acre.
34947	Fortress (OHP1701B) (isoxaben + dithiopyr)	Common Rush (<i>Juncus effusus</i>) 'Big Twister'	Field Container	Mathers	OH	2022	Over the top	Minor to moderate crop injury 4 and 6 weeks after first application of 1.125, 2.25, or 4.5 lb ai/a. Injury increased after second application, especially from two higher rates (moderate to severe 4 weeks after application).
34947	Fortress (OHP1701B) (isoxaben + dithiopyr)	Common Rush (<i>Juncus effusus</i>) 'Big Twister'	Field Container	Moretti	OR	2022	Over the top	Little to no injury from two applications at 150, 300 or 600 lb/a. Plant volume data variable and non-significant.
34947	Fortress (OHP1701B) (isoxaben + dithiopyr)	Common Rush (<i>Juncus effusus</i>)	Field Container	Witcher	TN	2022	Over the top	No injury from two applications at 150, 300 or 600 lb/a. Final average plant width was significantly lower with two lower rates.
33457	Fortress (OHP1701B) (isoxaben + dithiopyr)	Lilyturf, Big Blue (<i>Liriope muscari</i>) 'Big Blue'	Field Container	Marble	FL	2019	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
33457	Fortress (OHP1701B) (isoxaben + dithiopyr)	Lilyturf, Big Blue (<i>Liriope muscari</i>) 'Superblue'	Field Container	Senesac	NY	2019	Over the top	Minor to moderate injury with 150, 300 and 600 lb per acre applied twice; no stunting.
33457	Fortress (OHP1701B) (isoxaben + dithiopyr)	Lilyturf, Big Blue (<i>Liriope muscari</i>) 'Big Blue'	Field Container	Witcher	TN	2018	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
33459	Fortress (OHP1701B) (isoxaben + dithiopyr)	Muhly, Hairyaawn (<i>Muhlenbergia capillaris</i>)	Field Container	Derr	VA	2022	Over the top	No significant injury with 1.125 lb ai per acre

33459	Fortress (OHP1701B) (isoxaben + dithiopyr)	Muhly, Hairyawn (<i>Muhlenbergia capillaris</i>)	Field Container	Moretti	OR	2022	Over the top	Little to no injury and no significant plant volume reductions from two applications at 150, 300 or 600 lb/a.
33459	Fortress (OHP1701B) (isoxaben + dithiopyr)	Muhly, Hairyawn (<i>Muhlenbergia capillaris</i>)	Field Container	Senesac	NY	2019	Over the top	No injury or stunting with 150, 300 and 600 lb per acre applied twice.
33459	Fortress (OHP1701B) (isoxaben + dithiopyr)	Muhly, Hairyawn (<i>Muhlenbergia capillaris</i>)	Field Container	Witcher	TN	2018	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
33462	Fortress (OHP1701B) (isoxaben + dithiopyr)	Finestem Needlegrass (<i>Nassella tenuissima</i>)	Field Container	Cochran (IA)	IA	2019	Over the top	No significant injury or growth effects with 150, 300 and 600 lb per acre applied twice.
33462	Fortress (OHP1701B) (isoxaben + dithiopyr)	Finestem Needlegrass (<i>Nassella tenuissima</i>)	Field Container	Marble	FL	2020	Over the top	No injury with 150, 30, or 600 lb per acre.
33462	Fortress (OHP1701B) (isoxaben + dithiopyr)	Finestem Needlegrass (<i>Nassella tenuissima</i>)	Field Container	Senesac	NY	2019	Over the top	No injury or stunting with 150, 300 and 600 lb per acre applied twice.
33458	Fortress (OHP1701B) (isoxaben + dithiopyr)	Crimson Fountain Grass (<i>Pennisetum setaceum</i>) 'Fireworks'	Field Container	Senesac	NY	2019	Over the top	No injury with 150 and 300, very minor with 600 lb per acre applied twice; no stunting.
33458	Fortress (OHP1701B) (isoxaben + dithiopyr)	Crimson Fountain Grass (<i>Pennisetum setaceum</i>)	Field Container	Witcher	TN	2018	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
33450	Fortress (OHP1701B) (isoxaben + dithiopyr)	Sage, Russian (<i>Perovskia atriplicifolia</i>) 'Crazy Blue'	Field Container	Mathers	OH	2019	Over the top	Minor injury with 1.125, moderate with 2.25 and 4.5 lb ai per acre applied twice; minor growth reduction at all rates.
33450	Fortress (OHP1701B) (isoxaben + dithiopyr)	Sage, Russian (<i>Perovskia atriplicifolia</i>) 'Filigran'	Field Container	Senesac	NY	2019	Over the top	No injury or stunting with 150, 300 and 600 lb per acre applied twice.
33456	Fortress (OHP1701B) (isoxaben + dithiopyr)	Phlox, Creeping (<i>Phlox stolonifera</i>) 'Phlox Stolonifera'	Field Container	Mathers	OH	2020	Over the top	No injury with 1.125, 2.25, or 4.5 lb ai per acre with two application 6 weeks apart.
33448	Fortress (OHP1701B) (isoxaben + dithiopyr)	Sage (<i>Salvia</i> sp.) <i>S. sylvestris</i> 'May Night'	Field Container	Mathers	OH	2019	Over the top	Minor injury with 1.125, moderate with 2.25 and 4.5 lb ai per acre applied twice; moderate growth reduction at all rates.
33448	Fortress (OHP1701B) (isoxaben + dithiopyr)	Sage (<i>Salvia</i> sp.) 'May Night'	Field Container	Witcher	TN	2018	Over the top	No injury or growth reduction with 150, 300 and 600 lb per acre applied twice.
34949	Fortress (OHP1701B) (isoxaben + dithiopyr)	Prairie Dropseed (<i>Sporobolus heterolepis</i>)	Field Container	Derr	VA	2022	Broadcast	No to very slight injury with 1.125, 2.25, and 4.5 lb ai per acre.

Label Suggestions

For Fortress, it is suggested that the following crop species exhibiting no injury in the testing with over-the-top applications of Fortress be placed on the label.

Andropogon gerardii

Calamagrostis acutiflora

Hydrangea macrophylla

Hydrangea paniculata

Hydrangea quercifolia

Muhlenbergia capillaris

Nassella tenuissima

We also suggest that the 2 plant species exhibiting significant injury with over-the-top applications be added to the sensitive species list.

Digitalis grandiflora

Digitalis purpurea

Given the lack of phytotoxicity across virtually all plant species and genera, it is suggested that all the 7 plants in Table 4 (listed below) that showed no injury be added to the Fortress label if OHP possesses similar results on these crops:

Achillea millefolium

Achillea sp.

Chrysanthemum x rubellum

Coreopsis sp.

Dianthus gratianopolitanus

Juncus effusa

Liriope muscari

Appendix 1: Contributing Researchers

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