

Researcher: Hannah Mathers, PhD	Date: 2/18/2021
Project Title: 2019 In Season Pre-emergence Herbicide Crop Safety	
Protocol #: 19-012	PRnumbers: 33449, 33646, 33647, 33448, 33455, 33649, 33450

Narrative Summary (Results/Discussion)

Please keep text to one page if possible. Include summary of trial results and a brief discussion including how any changes from the protocol may have affected results. Results for multiple PRnumbers can be summarized together, but please list all PRNumbers in the header and in the summary data table.
dramatic

The results presented are for seven species *Coreopsis* 'Ladybird', *Hydrangea paniculata* 'Pinky Winky', *Hydrangea quercifolia* Jetstream™, *Salvia sylvestris* 'May Night', *Digitalis purpurea* 'Pam's Choice', *Achillea millefolium* 'New Vintage Rose', and *Perovskia atriplicifolia* 'Crazy Blue' (Table 2 A, B, C, D, E, F and G, respectively) that received applications of Fortress® (Isoxaben 0.50% + Dithiopyr 0.25%) (OHP, Inc., Mainland, PA 19451) (EPA Reg. #: 59807-19) as part of protocol 19-012. Of the seven species only *Coreopsis* 'Ladybird' and *Hydrangea quercifolia* Jetstream™ never had commercially unacceptable injury i.e., ≥ 3 (Table 2 A and C, respectively). *Coreopsis* 'Ladybird' had no statistically significant injury scores, versus the control, throughout the trial period (Table 2A). The ending delta growth index (GI) for the *Coreopsis* 'Ladybird' was statistically lower than the control (Table 2i) at 4X, but this lower delta GI was related to the larger size of the 4X plants at initiation, and therefore the lower delta GI, at 4X, was not considered commercially significant (Fig. 2.1). Conversely, the *Hydrangea quercifolia* Jetstream™ had significant injury scored at 4WAT, with the 4X rate (Table 2C) that caused a statistically significant growth reduction (GI) and delta GI at the trial conclusion for the 4X rate only (Table 2 iii) (Fig. 2.2). The *Hydrangea paniculata* 'Pinky Winky' had commercially (≥ 3) and statistically significant injury, scored four times, three at 1WAT (1, 2 and 3X), once at 1WA2T (4X); and once only statistically significant but not commercially at 2WAT (2X) (Table 2B). This visual injury occurring predominantly early in the trial (1 and 2 WAT), and in passing for one week after the second treatment (1WA2T)(Table 2B) did not result in any growth reduction at the trial's conclusion (Table 2ii)(Fig. 2.3). Therefore, Fortress can be used on *Hydrangea paniculata*, but growers need to accept some initial injury after a spring application that the plant outgrows, and some initial injury after a summer 2nd application and only if an overapplication occurs. The *Salvia sylvestris* 'May Night' did have commercially (≥ 3) and statistically significant injury, scored seven times, six were at the 4X rate with all evaluation dates at and after 2WAT (Table 2D) and once with the 2X rate 2WA2T. Three times the injury was scored only statically significant with the 2X rate (1WAT, 2WAT and 1WA2T) and once for the 4X rate at 1WAT (Table 2D). This injury did cause a commercially and statistically significant growth reduction (GI and delta GI) at the trial's end (Table 2iv) (Fig. 2.4).

Fortress caused extreme injury and death with the *Digitalis purpurea* 'Pam's Choice.' By the end of the trial only there was only one plant alive in each the 1X, 2X and 4X rates, which were all rated as 9.9 (Table 2E). The plants were injured at all rates after the first application but were all dead or not statistically different than dead (i.e., 10) at 4WAT (Fig. 2.5). No 2nd application was conducted since all but one plant in each treatment, besides those in the control, survived at 6WAT at ratings of 10 (dead) or 9 (almost dead) (Table 2D) (Fig. 2.5) All growth measures were at the trial end were for the one plant in each treatment still surviving, not an average (Table 2v). All delta heights and GI's were negative numbers indicating declines in growth (Table 2v). *Achillea millefolium* 'New Vintage Rose', and *Perovskia atriplicifolia* 'Crazy Blue' scored commercially (≥ 3) and statistically significant injury, four and two times, respectively (Table 2F and G). Both species had passing injury at 1WA2T; but the *Achillea* also had injury at 6WAT (Table 2F and G). The injury to both species did not significantly reduce height (Table 2vi and vii), but GI was impacted by the 4X rate with *Achillea* (Table 2 v) (Fig. 2.6) but not *Perovskia* (Fig. 2.7).

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Results Table

Please insert results table here. Include PRnumbers for each treatment if multiple PRnumbers are included in this summary. Please include product, active ingredient, and statistics.

Table 2A. Phytotoxicity ratings on selected ornamentals at Smith's Gardens, Inc., Delaware, OH.

Coreopsis 'Ladybird' #2 pots – **PR# 33449** – Smith's Gardens, Inc.

Treatment	Rate(ai) ^v	1 WAT ^z	2 WAT	4 WAT	6WAT	1 WA2T	2 WA2T	4 WA2T
Fortress [®]	1.125 lb	0.3	0.4	0.0	0.0✓	0.0	0.0	0.0
Fortress [®]	2.25 lb	0.2	1.0	0.0	0.0✓	0.0	0.0	0.0
Fortress [®]	4.50 lb	0.0	0.5	0.0	0.0✓	0.0	0.0	0.0
Untreated	--	0.5	0.8	0.0	0.0	0.0	0.0	0.0

Table 2B. Phytotoxicity ratings on selected ornamentals at Acorn Farms, Galena, OH.

Hydrangea paniculata 'Pinky Winky' #3 pots – **PR# 33646** – Acorn

Treatment	Rate(ai) ^v	1 WAT ^z	2 WAT	4 WAT	6WAT	1 WA2T	2 WA2T	4 WA2T
Fortress [®]	1.125 lb	4.1 *	0.0	0.0	0.0✓	0.0	0.0	0.0
Fortress [®]	2.25 lb	5.3 *	2.2 *	0.0	0.0✓	0.0	0.0	0.0
Fortress [®]	4.50 lb	5.5 *	1.3	0.0	0.0✓	4.0 *	0.0	0.0
Untreated	--	0.7	0.0	0.0	0.0	0.0	0.0	0.0

Table 2C. Phytotoxicity ratings on selected ornamentals at Acorn Farms, Galena, OH

Hydrangea quercifolia Jetstream™ #3 pots – **PR# 33647** – Acorn

Treatment	Rate(ai) ^v	1 WAT ^z	2 WAT	4 WAT	6WAT	1 WA2T	2 WA2T	4 WA2T
Fortress [®]	1.125 lb	1.2	0.0	0.0	0.0✓	1.3	2.2	1.2
Fortress [®]	2.25 lb	1.0	0.7	0.3	0.0✓	1.2	1.8	1.8
Fortress [®]	4.50 lb	1.4	0.3	2.5 *	0.0✓	1.2	1.8	1.8
Untreated	--	1.6	0.0	0.0	0.0	0.8	1.1	1.1

Table 2D. Phytotoxicity ratings on selected ornamentals at Smith's Gardens, Inc., Delaware, OH.

Salvia sylvestris 'May Night' #2 pots – **PR# 33448** - Smith's Gardens, Inc.

Treatment	Rate(ai) ^v	1 WAT ^z	2 WAT	4 WAT	6WAT	1 WA2T	2 WA2T	4 WA2T
Fortress [®]	1.125 lb	0.8	1.2	1.2	1.3✓	1.6	0.0	0.8
Fortress [®]	2.25 lb	2.6 *	2.9 *	1.4	1.3✓	2.1 *	3.0 *	0.3
Fortress [®]	4.50 lb	2.7 *	3.2 *	3.0 *	3.5✓ *	3.5 *	5.2 **	3.9 *
Untreated	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2E. Phytotoxicity ratings on selected ornamentals at Smith's Gardens, Inc., Delaware, OH.

Digitalis purpurea 'Pam's Choice' #2 - **PR# 33455** - Smith's Gardens, Inc.

Treatment	Rate(ai) ^v	1 WAT ^z	2 WAT	4 WAT	6WAT	7WAT	8WAT	10WAT
Fortress [®]	1.125 lb	0.7	1.2	8.9 **	8.9 **	9.3 **	9.3 **	9.9 **
Fortress [®]	2.25 lb	1.8 *	2.3 *	9.3 **	9.2 **	9.5 **	9.5 **	9.9 **
Fortress [®]	4.50 lb	2.8 *	3.3 *	9.2 **	9.2 **	9.2 **	9.2 **	9.9 **
Untreated	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 2F. Phytotoxicity ratings on selected ornamentals at Smith's Gardens, Inc., Delaware, OH.

Achillea millefolium 'New Vintage Rose' #2 pots - **PR# 33649** - Smith's Gardens, Inc.

Treatment	Rate(ai) ^v	1 WAT ^z	2 WAT	4 WAT	6WAT	1 WA2T	2 WA2T	4 WA2T
Fortress [®]	1.125 lb	0.0	0.0	0.0	0.4✓	0.4	0.0	0.0
Fortress [®]	2.25 lb	0.0	0.0	0.3	4.0✓ *	4.0 *	0.0	0.0
Fortress [®]	4.50 lb	0.0	0.0	2.2 *	3.3✓ *	3.3 *	0.0	0.0
Untreated	--	0.0	0.0	0.0	0.0✓	0.0	0.0	0.0

Table 2G. Phytotoxicity ratings on selected ornamentals at Smith's Gardens, Inc., Delaware, OH.

Perovskia atriplicifolia 'Crazy Blue' #2 pots - **PR# 33450** - Smith's Gardens, Inc.

Treatment	Rate(ai) ^v	1 WAT ^z	2 WAT	4 WAT	6WAT	1 WA2T	2 WA2T	4 WA2T
Fortress [®]	1.125 lb	0.0	0.3	0.0	0.0✓	1.4	0.0	0.0
Fortress [®]	2.25 lb	0.0	0.8	0.0	0.0✓	3.2 *	0.0	0.0
Fortress [®]	4.50 lb	0.0	2.0 *	0.5	0.5✓	3.8 *	2.5 *	0.0
Untreated	--	0.0	0.0	0.0	0.0✓	0.0	0.0	0.0

z = weeks after treatment

y = Phytotoxicity Ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable.

x = Phytotoxicity ratings followed by *,** are significantly different from control based on Dunnett's t-test (α = 0.10, 0.05, respectively).

^v = All rates for Gemini G (prodiamine 0.40% + isoxaben 0.25%) are listed as lb. per ac.

✓ indicates reapplication at this date.

Table 2i. Phytotoxicity ratings as a companion table to Table 2A above.

Coreopsis 'Ladybird' #2 pots - **PR# 33449** – Smith's Gardens, Inc.

Treatment	Rate (ai) ^v	HT ⁱ (cm) WAT ^z	HT4WA2T	GI ⁰ WAT ^z	GI4WA2T	Δ ^w HT	ΔGI
Fortress [®]	1.125 lb	10.4 ^y	16.8	2332.1	3166.4	6.4	834.3
Fortress [®]	2.25 lb	11.2	16.1	1916.3	2923.2	4.9	1006.9
Fortress [®]	4.50 lb	12.6	16.8	2554.3	2894.6	4.2	304.3 *
Untreated	--	12.4	13.9	1728.0	2938.1	1.5	1210.1

Table 2ii. Phytotoxicity measures as a companion table to Table 2B above.

Hydrangea paniculata 'Pinky Winky' #3 pots - **PR# 33646** - Acorn

Treatment	Rate (ai) ^v	HT ⁱ (in) WAT ^z	HT4WA2T	GI ⁰ WAT ^z	GI4WA2T	Δ ^w HT	ΔGI
Fortress [®]	1.125 lb	5.7 ^y	17.3	175.6	4463.9	11.6	4288.3
Fortress [®]	2.25 lb	5.4	16.2	181.7	4228.7	10.8	4047.0
Fortress [®]	4.50 lb	5.6	17.4	193.2	4403.6	11.8	4210.4
Untreated	--	6.2	17.2	222.0	4586.0	11.0	4364.0

Table 2iii. Phytotoxicity measures as a companion table to Table 2C above.

Hydrangea quercifolia Jetstream™ #3 pots - **PR# 33647** - Acorn

Treatment	Rate (ai) ^v	HT ⁱ (in) WAT ^z	HT4WA2T	GI ⁰ WAT ^z	GI4WA2T	Δ ^w HT	ΔGI
Fortress [®]	1.125 lb	8.8	15.7	849.4	2641.8	6.9	1792.4
Fortress [®]	2.25 lb	9.3	14.8	801.8	2371.9	5.5	1570.1
Fortress [®]	4.50 lb	9.5	15.3	608.1	1840.8 *	5.8	1232.7 *
Untreated	--	9.3	16.4	759.9	2840.5	7.1	2080.6

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Table 2iv. Phytotoxicity measures as a companion table to Table 2D above.

Salvia sylvestris 'May Night' #2 pots - **PR# 33448** - Smith's Gardens, Inc.

Treatment	Rate (ai) ^v	HT ⁱ (cm) WAT ^z	HT4WA2T	GI ^t OWAT ^z	GI4WA2T	Δ ^w HT	ΔGI
Fortress [®]	1.125 lb	2.3 ^y	18.1	485.7	8040.6	15.8	7554.9
Fortress [®]	2.25 lb	2.3	18.4	391.9	7979.2	16.1	7587.3
Fortress [®]	4.50 lb	2.4	18.5	377.3	6709.6	16.1	6332.3 *
Untreated	--	1.8	18.8	664.8	11636.9	17.0	10972.1

Table 2v. Phytotoxicity measures as a companion table to Table 2E above.

Digitalis purpurea 'Pam's Choice'#2 - **PR# 33455** - Smith's Gardens, Inc.

Treatment	Rate (ai) ^v	HT ⁱ (cm) WAT ^z	HT4WA2T	GI ^t OWAT ^z	GI4WA2T	Δ ^w HT	ΔGI
Fortress [®]	1.125 lb	13.0 ^y	6.0 *	2123.3	452.4 **	Neg. **	Neg. **
Fortress [®]	2.25 lb	12.3	3.0 **	2002.0	20.7 **	Neg. **	Neg. **
Fortress [®]	4.50 lb	13.3	3.0 **	1777.6	20.7 **	Neg. **	Neg. **
Untreated	--	12.0	15.1	1692.1	8816.7	3.1	7124.6

Table 2vi. Phytotoxicity measures as a companion table to Table 2F above.

Achillea millefolium 'New Vintage Rose' #2 pots - **PR# 33649** - Smith's Gardens, Inc.

Treatment	Rate (ai) ^v	HT ⁱ (cm) WAT ^z	HT4WA2T	GI ^t OWAT ^z	GI4WA2T	Δ ^w HT	ΔGI
Fortress [®]	1.125 lb	3.5 ^y	19.5	1334.3	4289.3	16.0	2955.0
Fortress [®]	2.25 lb	3.2	19.3	1339.5	4903.0	16.1	3563.5
Fortress [®]	4.50 lb	2.7	19.4	1049.4	3529.3	16.7	2479.9 *
Untreated	--	3.3	19.6	1463.0	4764.0	16.3	3301.0

Table 2vii. Phytotoxicity measures as a companion table to Table 2G above.

Perovskia atriplicifolia 'Crazy Blue' #2 pots - **PR# 33450** - Smith's Gardens, Inc.

Treatment	Rate (ai) ^v	HT ⁱ (cm) WAT ^z	HT4WA2T	GI ^t OWAT ^z	GI4WA2T	Δ ^w HT	ΔGI
Fortress [®]	1.125 lb	7.2 ^y	29.9	502.2	10715.7	22.7	10213.5
Fortress [®]	2.25 lb	7.3	29.3	480.9	10188.6	22.0	9707.7
Fortress [®]	4.50 lb	6.5	27.2	633.7	10383.0	20.7	9749.3
Untreated	--	7.0	30.3	503.3	11290.8	23.3	10787.5

y = All measures are in centimeters (cm) and the calculated Growth Index measures are in cm³.

x = Measures followed by *, ** are significantly different from control based on Dunnett's t-test (α = 0.10, 0.05, respectively).

v = All rates for Gallery SC (Isoxaben 45.45%) are listed as active ingredient (ai) per ac.

i = HT represents Height at start of trial and at the end of the trial or 4WA2T measured in cm.

t = GI represents Growth index (cm³) and was calculated as GI = Pi (Ht)(r²), where Ht. (cm) at start and final height, respectively, r was half of the average of W1+W2 (two perpendicular measurements of plant diameter (cm)) and Pi was "π" to determine plant volume.

Materials & Methods/Recordkeeping

Please fill out the information below or attach a separate document with comparable information.

Protocol 19-012 was followed with no changes, including four replications with three plants per replication and four treatments per species. 0, 1, 2 and 4X rates of Fortress[®] (Isoxaben 0.50% + Mathers Table 1 2019

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Dithiopyr 0.25%) (OHP, Inc., Mainland, PA 19451) (EPA Reg. #: 59807-19) with 3-gallon containers for *Hydrangea paniculata* 'Pinky Winky' and *Hydrangea quercifolia* Jetstream™ (Table 2B and C) and 3-gallon pots for *Coreopsis* 'Ladybird', *Salvia sylvestris* 'May Night', *Achillea millefolium* 'New Vintage Rose', and *Perovskia atriplicifolia* 'Crazy Blue' (Table 2, A, D, F and G) for 48 plants per protocol (PR#: 33449, 33646, 33647, 33448, 33649 and 33450). Evaluations were conducted at 1, 2 and 4 weeks after treatment (WAT). A reapplication was conducted at 6 WAT except for the *Digitalis purpurea* 'Pam's Choice' (Table 2E) (PR#: 33455) and evaluations occurred 1, 2, and 4 weeks after second treatment (WA2T), except for the *Digitalis*. The *Digitalis purpurea* 'Pam's Choice' were scoring 9 or 10's in all treatments at 6WAT so no reapplication was conducted. Rates are listed in pounds of active ingredient (a.i)/ acre with 1X being 1.125 lb ai/ac (Table 2A, B, C, D, E, F and G). The two *Hydrangea* species were located at Acorn Farms Inc., 7679 Worthington Rd., Galena, OH and the five other species were located at Smith's Gardens, Inc., Delaware, OH. Weather records for Columbus, OH are presented as Galena and Delaware, OH are in the greater Columbus, OH region. All plants were grown in standard container media (85% pine bark and 15% Comtil) (Kruz Bros. Central Ohio, LLC, Groveport, OH) and fertilized with The Anderson's 18-6-12 + minors, slow-release 8-9-month formulation and over-head irrigation. Applications at Acorn Farms were initiated on June 7, 2019. The five species at Smith's Gardens, Inc. were initiated on May 10, 2019. All herbicides were applied within 7 days after potting as over the top applications and all were watered within 2 hours following applications.

Name(s) of Personnel Conducting Research: Dr. Hannah Mathers
Location of Trial (city/state): Acorn Farms Inc., Galena, OH and Smith's Gardens, Inc., Delaware, OH
Use Site (greenhouse/shade house/field container/etc.): Field container

Crop History

Crop Cultivar/Variety:	Coreopsis 'Ladybird'
Purchased from:	Smith's Gardens, Inc., Delaware, OH
Date of Transplanting:	May 3, 2019
Potting Mix:	See above
Pot size & spacing:	2-gallon pots on 1-foot centers
Crop Cultivar/Variety:	<i>Hydrangea paniculata</i> 'Pinky Winky'
Purchased from:	Bailey Nurseries, Inc., Saint Paul, MN
Date of Transplanting:	May 30, 2019
Potting Mix:	See above
Pot size & spacing:	3-gallon pots on 2-foot centers
Crop Cultivar/Variety:	<i>Hydrangea quercifolia</i> Jetstream™
Purchased from:	Bailey Nurseries, Inc., Saint Paul, MN
Date of Transplanting:	May 30, 2019
Potting Mix:	See above

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Pot size & spacing:	3-gallon pots on 2-foot centers
Crop Cultivar/Variety:	<i>Salvia sylvestris</i> 'May Night'
Purchased from:	Smith's Gardens, Inc., Delaware, OH
Date of Transplanting:	May 3, 2019
Potting Mix:	See above
Pot size & spacing:	2-gallon pots on 1-foot centers
Crop Cultivar/Variety:	<i>Digitalis purpurea</i> 'Pam's Choice'
Purchased from:	Smith's Gardens, Inc., Delaware, OH
Date of Transplanting:	May 3, 2019
Potting Mix:	See above
Pot size & spacing:	2-gallon pots on 1-foot centers
Crop Cultivar/Variety:	<i>Achillea millefolium</i> 'New Vintage Rose'
Purchased from:	Smith's Gardens, Inc., Delaware, OH
Date of Transplanting:	May 3, 2019
Potting Mix:	See above
Pot size & spacing:	2-gallon pots on 1-foot centers
Crop Cultivar/Variety:	<i>Perovskia atriplicifolia</i> 'Crazy Blue'
Purchased from:	Smith's Gardens, Inc., Delaware, OH
Date of Transplanting:	May 3, 2019
Potting Mix:	See above
Pot size & spacing:	2-gallon pots on 1-foot centers

Product(s) applied prior to start of experiment:

Product	Rate	Application Type	Date of Application	Crop Growth Stage
Fortress®	0			Shoot expansion
	150 lb/ac (1.125 lb a.i./ac)	Granular: pre-weighed according to pot dia. and rate	05/10/2019 for: <i>Coreopsis</i> , <i>Salvia</i> , <i>Digitalis</i> , <i>Achillea</i> and <i>Perovskia</i> . 06/07/2019 for: <i>Hydrangea paniculata</i> and <i>H. quercifolia</i>	Shoot expansion

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	300 lb/ac (2.25 lb a.i./ac)	Granular: pre-weighed according to pot dia. and rate	05/10/2019 for: <i>Coreopsis</i> , <i>Salvia</i> , <i>Digitalis</i> , <i>Achillea</i> and <i>Perovskia</i> . 06/07/2019 for: <i>Hydrangea paniculata</i> and <i>H. quercifolia</i>	Shoot expansion
	600 lb/ac (4.50 lb a.i./ac)	Granular: pre-weighed according to pot dia. and rate	05/10/2019 for: <i>Coreopsis</i> , <i>Salvia</i> , <i>Digitalis</i> , <i>Achillea</i> and <i>Perovskia</i> . 06/07/2019 for: <i>Hydrangea paniculata</i> and <i>H. quercifolia</i>	Shoot expansion

Experiment Information

Experimental Design: Completely randomized design with species
Number of Reps: Four replicates with three plants per replicate or 12 plants/tmt/rate/species

Photos



Fig. 2.1. and B. (Left) *Coreopsis* 'Ladybird' #2 pots (PR# 33449) at Smith's Gardens, Inc., Delaware, OH. **A.** Photo taken on June 7, 2019 or 4WAT and **B.** Photo taken on July 5, 2019 or 2WA2T applications of Fortress®. From left to right 0 (Control), 1X, 2X and 4X are shown in both **A** and **B**. Although the delta growth index (GI) for 4X treatments were lower than the controls (Table 2i) no commercially unacceptable injury or growth reduction was attributed to the Fortress®. Although the 4X treatment plants had more flowers and were more compact and presented as commercially more attractive plants (Table 1i) and **B** (far right). Photo taken by: H. Mathers.

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Fig. 2.2. A and B (Above) *Hydrangea paniculata* 'Pinky Winky' in #3 pots (PR# 33646) located at Acorn Farms, Galena, OH. **A.** Photo taken on June 21, 2019 or 2WAT and **B.** taken on August 2, 2019 or 2WA2T applications of Fortress®. **A.** From left to right 0 (Control), 1X, 2X and 4X are shown for **A.** There was injury to the 'Pinky Winky' at 1WAT and at 2WAT (**B**), but all were growing out of the injury by 2WAT. The 2X plants were still statistically injured compared to the controls at 2WAT but not the 4X, and neither 2X nor 4X, at two weeks after, were commercial unacceptable compared to the controls. **B.** From left to right 4X, 2X, 1X and 0X (control) are shown. The 4X treatment had statistical and commercially significant passing injury from 1 WA2T, but by the trial's end showed no injury relative to the control (Table 2B). There was no lasting impact on heights or GI of the early injury, or the injury at 1WA2T, with the 4X (Table 2ii). All plants were considered equivalent to the controls in delta Ht. and GI. Photo taken by: H. Mathers.

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Fig. 2.3. and B. (Above) *Hydrangea quercifolia* Jetstream™ #3 pots ((PR#33647) located at Acorn Farms, Galena, OH. **A.** Photo taken on July 5, 2019 or 4WAT applications of Fortress®. **B.** Photo taken on August 2, 2019 or 2WA2T. From left to right 0 (Control), 1X, 2X and 4X plants are shown in **A** and **B**. Fortress® caused statistically significant injury with the 4X treatment at 4WAT and this did cause a significant GI and delta GI reduction at the trial's conclusion (Table 2 iii). However, all treatments were growing vigorously by the trial conclusion and were scored with no commercially unacceptable injury (Table 2 C). Photo taken by: H. Mathers.

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Fig. 2.4. A. and B. (Above) *Salvia sylvestris* 'May Night' in #2 pots (PR# 33448) at Smith's Gardens, Inc., Delaware, OH. **A.** Photo taken on May 17, 2019 or 1WAT and **B.** taken on July 5, 2019 or 2WA2T applications of Fortress®. From left to right 0 (Control), 1X, 2X and 4X are shown in both **A** and **B**. **A.** The *Salvia sylvestris* 'May Night' suffered significant injury starting at 1WAT that continued with the 2X and 4X treatment until 4WA2T for the 4X plants and to 2WAT for the 2X plants (Table 2D). Although the delta growth index (GI) for 4X treatments were lower than the controls (Table 2i) no commercially unacceptable injury or growth reduction was attributed to the Fortress®. Although all 1X, 2X and 4X plants had smaller GI's relative to the control, only the 4X GI and delta GI were considered statistically significant (Table 2iv) and commercially unacceptable visually (Table 2D). As with the *Coreopsis* the controls were larger plants, but their flowering was uneven and less than in the 1X, 2X and 4X treatment plants. The 1X and 2X presented as commercially more attractive than the controls (Table 1i). Although the 4X plants had more flowers vs the controls, they were significantly smaller **B** (far right) and considered commercially unacceptable (Table 2D). Photo taken by: H. Mathers.

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Fig. 2.5. A, B, (Above) and C. (Right) *Digitalis purpurea* 'Pam's Choice' #2 pots (PR# 33455) at Smith's Gardens, Inc., Delaware, OH. **A.** Photo taken on May 24, 2019 or 2WAT showing injury caused by Fortress®, at 2X and 4X rates versus the control (0) was intensifying with whole leaf chlorosis. **B.** Photo taken on June 10, 2019 or 4WAT showing Fortress® caused death to all but one plant in each of the 1X, 2X, and 4X treatments. **C.** Photo was taken at 6WAT and shows only the control plants were alive. All the 1X, 2X or 4X plants were dead or not statistically different than dead (Table 2E). No reapplication was conducted and growth measures at the trial's completion showed negative growth for all delta measures (Table 2v). Photo taken by: H. Mathers.

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Fig. 2.6. and B. *Achillea millefolium* 'New Vintage Rose' in #2 pots (PR# 33649) at Smith's Gardens, Inc., Delaware, OH. **A.** Photo taken on June 21, 2019 or at reapplication 6WAT and **B.** taken on July 5, 2019 or 2WA2T after applications of Fortress®. From left to right 0 (Control), 1X, 2X and 4X are shown in both **A** and **B**. Although the growth index (GI) and delta GI were significant for the 4X treatments (Table 2vi) and no commercially unacceptable injury was scored for any treatment at the trial's conclusion (Table 2F) very few stems relative to the control and 1X plants were formed in the 2X or 4X plants. However, only the 4X plants were smaller at initiation, and thus were significant for injury with Fortress® at 4X, **B.** (far right). Photo taken by: H. Mathers.

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Fig. 2.7. *Perovskia atriplicifolia* 'Crazy Blue' in #2 pots (PR# 33450) at Smith's Gardens, Inc., Delaware, OH. Although there was some passing statistical and commercial significant injury at one week after the second application, by the next week (shown above) photo taken on July 5, 2019 or 2WA2T applications of Fortress® (left to right: 0 (Control), 1X, 2X and 4X) (Table 2G) there was lasting impact of the second application on the plants. There were no significant growth reductions as GI or height (cm), or their respective delta values caused by the Fortress® treatments (Table 2vii). All plants at the end of the trial were growing vigorously with equal numbers of flowers and stems. Photo taken by: H. Mathers.

Data Collected

Please describe data collected and scoring system. Also include the dates data were collected.

All rated score evaluations of phytotoxicity (defined in report) were measured on a 0 to 10 scale where 0 representing no phytotoxicity, ≥ 3 represents commercially unacceptable injury, and 10 represented plant death (Barolli et al., 2005; Collins et al. 1999; Duray and Davies, 1989; Mathers and Case, 2010; Samtami et al., 2007). This rated score is a standard measure accepted in all major weed and horticultural science journals with each interval representing a 10% increase in injury over the whole plant (ex. 3 would be 30% injury, and 5 would be 50%, etc.). Starting and ending heights, and two perpendicular measurements of diameter were taken per plant. These measures were used to calculate for the two *Hydrangea* species, Growth index (GI) (in^3) as $GI = \pi (Ht)(r^2)$, where Ht.(in), was the starting or ending height, (r) was half of the average of W1+W2 [two perpendicular measurements taken of plant diameter (in)] and (π) was “ π ”. For the *Coreopsis*, *Salvia*, *Digitalis*, Mathers Table 1 2019



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Achillea and *Perovskia*, Growth index (GI) (cm^3) as $GI = \pi (Ht)(r^2)$, where Ht.(cm), was the starting or ending height, (r) was half of the average of W1+W2 [two perpendicular measurements taken of plant diameter (cm)] and (π) was " π ". The GI provides a volume measure of the plant which helps with quality determinations not necessarily evident by heights and widths alone or by visual observations. Symptoms were also noted if significant, and photos were conducted *in situ*.

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Raw Data

See attached excel files

Environmental conditions during the experiment:

Insert temperature, precipitation and/or irrigation, and relative humidity with a minimum of high, low and average daily temperatures. Or send separate file with this information.

Include a statement about any significant weather or environmental events during the experiment.

Source: <https://www.wunderground.com/history/monthly/us/oh/columbus/KCMH/date/2019-5> { or 2019-6, or 2019-7 or 2019-8}

Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (cm)
	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
1	83	68.7	53	61	56.9	52	96	69.2	41	29	11.6	0	29.2	29.2	29.1	0.00
2	77	65.6	59	62	60.5	58	100	85.1	57	14	4.5	0	29.3	29.2	29.2	0.09
3	69	63.1	54	62	59.9	53	97	89.4	68	14	4.7	0	29.2	29.1	29.0	0.01
4	56	54.2	51	54	51.7	50	100	91.3	86	13	6.5	0	29.1	29.0	29.0	0.30
5	66	52.9	0	51	45.8	0	97	75.6	0	15	8.9	3	29.1	29.0	28.9	0.21
6	75	60.9	44	49	45.8	42	93	61.8	37	10	3.3	0	29.2	29.2	29.1	0.00
7	77	63.9	53	54	50.4	48	86	63.8	36	15	5.0	0	29.3	29.2	29.2	0.00
8	80	65.1	50	54	48.5	41	77	56.9	39	12	7.3	3	29.3	29.2	29.1	0.00
9	79	70.5	63	63	58.6	52	93	67.2	51	23	13.3	5	29.1	29.0	29.0	0.00
10	63	59.1	50	62	53.4	42	97	82.3	62	15	9.3	3	29.3	29.1	29.0	0.73
11	67	55.7	44	46	42.9	40	89	64.3	45	15	8.7	0	29.3	29.1	28.9	0.00
12	56	50.7	46	51	47.9	44	96	90.3	77	14	6.5	0	28.9	28.9	28.8	0.16
13	56	51.4	46	49	46.3	43	97	83.1	66	17	9.5	5	29.1	28.9	28.8	0.11
14	65	54.0	42	44	39.9	37	93	63.2	37	13	6.8	0	29.2	29.1	29.1	0.01
15	71	59.1	44	47	42.1	39	90	57.9	32	13	6.0	0	29.1	29.1	29.1	0.00
16	75	65.7	53	55	50.2	47	83	59.6	37	15	7.5	0	29.1	29.1	28.9	0.00



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Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (cm)
17	80	67.1	61	66	61.0	57	97	82.3	52	16	8.6	0	29.1	29.0	28.9	0.93
18	86	73.5	63	65	61.6	59	93	69.4	40	37	8.7	0	29.1	29.1	29.0	0.01
19	83	73.6	67	63	60.2	54	84	64.6	40	26	12.1	5	29.0	29.0	28.9	0.00
20	69	62.4	52	60	52.7	44	93	72.0	51	18	11.8	6	29.2	29.1	29.0	0.05
21	64	55.0	47	44	40.8	36	86	60.6	41	14	8.6	0	29.3	29.2	29.2	0.00
22	84	68.8	53	66	54.9	42	84	62.2	43	17	9.6	0	29.2	29.2	29.1	0.00
23	82	72.9	67	67	64.7	61	90	76.1	58	23	10.6	0	29.3	29.2	29.1	0.00
24	80	71.0	58	63	56.9	51	90	62.3	46	8	4.0	0	29.3	29.2	29.2	0.08
25	88	75.0	65	68	64.0	61	90	70.2	40	21	9.3	0	29.2	29.2	29.1	0.00
26	84	72.2	65	65	62.9	60	93	74.3	49	22	6.7	0	29.2	29.1	29.1	0.00
27	81	71.4	65	67	60.7	54	90	71.2	44	16	7.3	0	29.2	29.1	28.9	0.13
28	88	74.7	67	67	64.8	61	93	74.3	43	20	9.2	0	29.0	28.9	28.9	0.61
29	81	75.9	70	69	65.0	61	84	69.8	52	21	9.9	0	28.9	28.9	28.9	0.00
30	74	70.0	66	67	63.8	57	96	81.0	66	18	7.5	0	29.0	28.9	28.9	0.09
31	79	68.3	61	63	60.1	56	96	77.0	45	21	4.7	0	29.0	29.0	28.9	0.01

Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (in)
Jun	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
1	81	67.5	59	63	59.8	57	100	79.9	44	16	5.8	0	29.0	29.0	28.9	0.22
2	74	67.3	60	62	57.4	42	97	72.1	48	17	8.6	0	29.1	28.9	28.9	0.00
3	70	61.0	49	45	40.8	37	80	48.9	33	14	7.4	0	29.3	29.2	29.1	0.00
4	78	66.8	54	55	48.8	41	69	53.3	39	14	6.9	0	29.3	29.2	29.1	0.00
5	80	71.7	65	67	62.7	55	93	73.5	61	16	9.4	3	29.1	28.9	28.9	0.03
6	82	71.6	64	65	62.5	60	93	74.4	47	10	5.3	0	29.0	29.0	28.9	0.09
7	77	69.8	63	62	58.5	52	90	68.8	51	16	9.9	3	29.1	29.0	29.0	0.00
8	77	71.4	67	61	57.4	53	73	61.5	52	16	12.3	9	29.1	29.1	29.1	0.00



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Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (in)
9	81	74.5	69	66	60.8	57	76	62.4	54	18	11.8	7	29.1	29.1	29.1	0.00
10	76	69.7	59	70	61.3	48	90	74.8	58	23	12.8	6	29.3	29.1	29.0	0.00
11	78	65.0	49	50	45.8	42	93	55.0	29	14	5.4	0	29.4	29.3	29.2	0.06
12	77	64.9	57	61	52.2	44	96	67.0	37	20	10.5	5	29.3	29.1	28.9	0.00
13	64	59.2	53	59	52.6	45	93	79.5	60	24	14.4	0	29.1	28.9	28.8	0.53
14	74	63.3	49	46	42.6	39	83	50.9	28	17	10.5	3	29.3	29.2	29.1	0.00
15	76	67.7	61	66	57.0	46	93	69.8	48	20	8.5	3	29.1	29.1	29.0	0.00
16	79	71.0	66	70	66.5	64	100	86.2	64	21	9.6	3	29.0	29.0	28.9	0.93
17	77	70.8	66	70	66.4	64	94	86.4	66	13	5.9	0	29.1	29.1	29.0	0.18
18	78	70.6	67	70	66.4	65	97	86.9	66	12	5.1	0	29.1	29.1	29.0	0.75
19	82	72.0	67	70	67.5	65	97	86.3	60	17	4.9	0	29.0	28.9	28.8	0.26
20	76	68.5	64	67	64.8	60	97	88.1	69	23	10.9	5	28.9	28.8	28.7	2.66
21	77	68.0	61	61	54.9	51	90	65.3	42	14	8.0	3	29.1	29.1	28.9	0.01
22	80	71.2	64	57	52.3	49	75	52.5	38	12	6.5	3	29.2	29.2	29.1	0.00
23	82	71.4	55	66	54.3	47	89	57.7	32	10	5.2	0	29.2	29.1	29.0	0.00
24	83	72.4	68	70	66.8	64	96	83.2	54	16	8.9	5	29.0	28.9	28.8	0.34
25	84	75.1	66	65	60.1	55	93	62.8	38	16	10.2	5	29.1	29.1	28.9	0.86
26	89	78.6	68	66	62.3	60	78	59.0	38	13	6.8	0	29.3	29.2	29.2	0.00
27	87	77.5	71	68	64.9	61	84	66.3	48	18	5.1	0	29.3	29.3	29.3	0.00
28	90	79.3	70	69	65.3	62	90	65.0	39	12	5.6	0	29.4	29.3	29.2	0.00
29	91	81.0	69	67	64.6	63	84	59.2	39	17	8.4	0	29.3	29.2	29.1	0.00
30	89	80.3	72	70	63.8	59	84	59.0	37	14	6.3	0	29.1	29.1	29.1	0.00

Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (in)
Jul	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
1	89	78.2	65	68	61.0	57	81	57.4	39	9	5.0	0	29.2	29.1	29.1	0.00
2	93	80.0	70	73	67.3	64	90	67.5	39	25	7.1	0	29.1	29.1	29.0	0.00



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Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (in)
3	84	73.2	69	72	68.9	67	97	87.0	58	14	6.8	0	29.1	29.1	29.1	0.35
4	86	73.3	67	71	68.4	66	100	86.1	51	9	3.1	0	29.2	29.1	29.1	0.51
5	90	81.1	71	74	70.6	68	96	71.8	50	14	5.5	0	29.2	29.2	29.1	0.00
6	90	79.7	74	73	71.1	69	94	76.6	52	29	6.1	0	29.1	29.1	29.0	0.03
7	86	77.0	72	72	69.8	63	93	79.3	59	16	5.3	0	29.1	29.1	29.0	0.28
8	85	75.8	67	66	61.8	55	79	62.9	47	13	8.4	5	29.1	29.1	29.1	0.07
9	88	77.3	64	70	62.2	52	76	60.0	49	8	3.3	0	29.2	29.1	29.1	0.00
10	90	81.9	71	71	67.6	65	91	64.3	43	10	4.3	0	29.1	29.1	29.1	0.00
11	90	80.8	75	73	67.8	60	84	66.0	43	17	6.7	0	29.0	29.0	28.9	0.00
12	85	75.8	68	66	62.5	58	87	65.2	40	9	5.5	0	29.1	29.0	29.0	0.32
13	89	77.7	64	63	58.4	52	93	56.5	28	10	4.0	0	29.2	29.1	29.1	0.00
14	90	80.4	71	68	65.1	62	78	60.5	43	12	5.3	0	29.3	29.2	29.2	0.00
15	92	80.8	71	69	65.9	62	79	61.9	39	13	5.1	0	29.3	29.2	29.2	0.00
16	90	78.9	72	73	69.2	67	94	73.7	46	17	8.2	3	29.2	29.1	29.1	0.00
17	86	77.3	73	75	72.4	70	94	85.3	65	18	8.4	0	29.1	29.1	29.0	0.31
18	90	79.5	71	72	70.3	68	97	75.2	52	10	4.2	0	29.1	29.1	29.0	0.44
19	92	81.6	73	77	73.1	70	93	76.5	54	15	7.6	0	29.1	29.1	29.1	0.00
20	94	85.2	76	75	72.0	68	91	66.4	43	21	8.6	0	29.1	29.1	29.1	0.00
21	92	82.4	73	73	70.8	66	96	69.2	47	20	8.3	0	29.1	29.1	29.0	0.00
22	76	72.7	68	72	68.5	63	96	86.8	68	16	7.7	0	29.1	29.0	29.0	0.79
23	78	69.3	60	62	52.8	41	90	59.3	29	15	7.9	0	29.2	29.1	29.1	0.07
24	78	68.4	58	58	56.1	54	90	66.5	45	12	5.7	0	29.3	29.2	29.1	0.00
25	81	70.8	57	59	55.0	51	93	60.8	35	8	3.6	0	29.4	29.3	29.3	0.00
26	84	73.6	61	60	57.3	55	90	59.8	39	10	3.3	0	29.4	29.4	29.3	0.00
27	87	76.7	64	63	60.3	57	87	59.9	37	17	6.8	0	29.4	29.3	29.3	0.00
28	89	79.2	69	65	62.9	60	84	59.5	40	17	8.5	0	29.3	29.3	29.2	0.00



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Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (in)
29	89	79.7	69	67	63.8	59	87	60.6	37	17	8.8	3	29.2	29.1	29.1	0.00
30	85	75.8	70	69	67.0	64	93	74.9	49	13	7.6	3	29.2	29.1	29.1	0.05
31	87	76.8	68	66	64.2	61	93	67.6	41	13	4.9	0	29.2	29.2	29.1	0.00

Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (in)
Aug	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
1	84	75.6	69	65	62.9	60	87	66.6	44	14	7.1	0	29.3	29.2	29.2	0.00
2	87	76.8	67	61	58.0	56	73	54.1	36	10	6.6	0	29.2	29.2	29.2	0.00
3	87	75.1	63	61	56.6	50	87	56.1	28	9	5.8	0	29.2	29.2	29.1	0.00
4	89	75.1	61	67	58.1	50	90	59.8	30	26	5.5	0	29.2	29.1	29.1	0.00
5	89	78.2	67	68	63.9	59	93	64.1	39	15	4.6	0	29.1	29.1	29.0	0.71
6	86	75.2	68	69	65.2	60	93	72.8	43	18	7.5	0	29.1	29.0	28.9	0.01
7	84	75.9	68	68	64.3	55	96	69.5	37	15	7.3	0	29.0	29.0	28.9	0.11
8	89	77.5	65	67	62.1	60	87	61.3	39	26	11.3	0	29.0	29.0	28.9	0.00
9	83	73.6	65	65	54.5	46	90	55.7	29	10	6.1	3	29.1	29.1	29.0	0.01
10	83	71.1	60	58	54.5	51	87	59.0	34	12	5.6	0	29.2	29.1	29.1	0.00
11	84	72.6	58	59	55.0	53	90	56.7	35	8	4.3	0	29.2	29.2	29.1	0.00
12	85	76.5	65	65	60.0	56	84	58.0	38	12	5.7	0	29.1	29.1	29.0	0.00
13	83	75.6	71	72	69.6	65	96	81.9	63	14	8.1	3	29.0	28.9	28.9	0.29
14	85	74.6	68	69	65.5	60	96	75.9	43	12	4.8	0	29.1	29.0	29.0	0.00
15	85	76.0	67	66	62.5	58	93	65.8	40	15	7.6	0	29.1	29.1	29.0	0.00
16	84	75.8	64	65	61.4	53	93	63.4	34	12	4.7	0	29.1	29.1	29.1	0.00
17	90	77.8	67	69	64.5	61	87	65.4	39	16	5.8	0	29.1	29.1	29.1	0.00
18	93	82.0	72	69	67.8	65	87	64.3	41	36	7.7	0	29.1	29.1	29.0	0.00
19	89	76.2	66	70	65.9	63	93	72.2	46	20	6.4	0	29.2	29.1	29.1	0.50
20	91	79.7	71	71	68.4	66	90	69.3	48	18	6.2	0	29.2	29.1	29.1	0.00
21	85	75.5	69	67	65.6	64	90	72.7	49	15	7.8	3	29.1	29.1	29.1	0.01



Ornamental Horticulture Program Research Report Form

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Researcher: Hannah Mathers, PhD **Date:** 2/18/2021
Project Title: 2019 In Season Pre-emergence Herbicide Crop Safety
Protocol #: 19-012 **PRnumbers:** 33449, 33646, 33647, 33448, 33455, 33649, 33450

Time	Temperature (° F)			Dew Point (° F)			Humidity (%)			Wind Speed (mph)			Pressure (Hg)			Precipitation (in)
22	78	72.2	69	69	66.5	62	93	82.7	66	13	6.4	0	29.1	29.1	29.1	0.00
23	76	68.1	59	61	54.4	50	79	63.2	40	16	8.3	3	29.3	29.2	29.1	0.27
24	77	66.2	55	55	50.7	47	89	60.5	36	14	7.9	0	29.4	29.3	29.3	0.00
25	80	68.1	57	55	52.1	50	78	58.6	38	13	8.8	5	29.3	29.3	29.2	0.00
26	68	65.6	63	65	60.2	52	97	83.3	65	15	9.9	7	29.2	29.1	29.1	0.00
27	76	70.6	67	70	68.0	65	97	91.8	79	16	7.5	0	29.1	29.0	29.0	0.61
28	79	69.9	63	70	58.8	47	100	73.0	33	17	6.0	0	29.1	29.1	29.0	0.76
29	81	69.4	57	58	54.6	52	93	62.3	36	17	6.8	0	29.2	29.1	29.1	0.00
30	87	74.9	66	65	60.4	55	79	62.0	33	13	6.9	3	29.3	29.2	29.1	0.00
31	77	69.8	66	60	56.9	54	79	64.0	46	12	6.6	0	29.4	29.3	29.3	0.00