

# FINAL PERFORMANCE REPORT



## For Specialty Crop Block Grant Program Projects Funded in Federal Fiscal Year 2018

### ANNUAL PROJECT REPORT TEMPLATE

#### PROJECT INFORMATION

<b>Project Title</b>	Nursery Tree Lives Matter: Drift from Spraying Stacked Herbicide Resistant Crops
<b>Recipient Organization Name:</b>	Minnesota Nursery & Landscape Association
<b>Period of Performance</b>	<b>Start Date:</b> 12/10/2018 <b>End Date:</b> 10/30/2020

#### Recipient's Project Contact

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#### PERFORMANCE NARRATIVE

##### PROJECT BACKGROUND

*Provide enough information for the reader to understand the importance or context of the project. This section may draw from the background and justification contained in the approved project proposal.*

Minnesota (MN) in 2017 ranked 4th in national pesticide use complaints with 171 state investigations concluded (Farm Journal, AGPro, Sept. 2017). This high ranking was due to MN ranking 2nd for corn silage and 3rd for soybean production in the United States (US). Many agricultural producers are unaware of the off-target susceptibility of nursery crops to row-crop herbicide drift. Specialty crop farmers and especially nursery growers in MN and across the United States are concerned that the increased use of glyphosate and dicamba to control weeds in agronomic crops will result in more crop losses due to drift (Kruger et al. 2011). In MN, many nurseries are within proximity of agronomic crop fields. Studies have shown that off-target movement from an unshielded sprayer ranges from 1 to 16% of the target dose; however, boom height and wind have been found to double or triple these doses. Therefore, our studies used concentrations of 0, 6, 18 and 54% for glyphosate drift and 0, 6, 18 and 36% for dicamba. Dicamba is applied to genetically modified crops, which already have glyphosate resistance; therefore, the potential for interactive effects on nurseries is of particular interest. Relating ppm's disclosed in laboratory analyte foliar residue samples collected by various state agriculture departments after drift events to injury symptom, development, and growth reduction is critical to understanding this extremely critical and current issue in crop production and environmental protection. From personal communication with nursery owners who have had drift injury from row crops (Raemelton Farms, MD; Ammon Wholesale Nursery, KY; and, Meranda Nixon Winery, OH), the average time from the drift event to sample collection is 6 WAT.

##### ACTIVITIES PERFORMED

*Address the below sections as they relate to the entire project's period of performance.*

## OBJECTIVES

#	Objective	Completed?	
		Yes	No*
1	Evaluate Roundup Power Max at various drift rates i.e., 0%, 6%, 18%, 54%) applied in early June 2018 (i.e., before the dicamba spraying restriction deadline implemented by MDA of June 20) on three commercially important nursery field grown species including red maple, linden and tree lilac at Bailey Nurseries at two farms. Additionally, evaluate a tank mix of Power Max with a group 15 herbicide at two rates. Originally, Atrazine was to be evaluated as well but this was not done, due to COVID travel restrictions and budget constraints for analyte testing. Moreover, three Bailey Farms were evaluated, exceeding objective 1.	100% +	
2	Evaluate XtendiMax with Vapor Grip Technology at various drift rates of 0, 6, 18 and 36%, and tank mixed with Roundup PowerMax applied in early June 2018 (i.e., before the dicamba spray date restriction in MN) on three commercially important nursery field grown species including red maple, linden and tree lilac at Bailey Nurseries at two farms. Plus evaluate the tank mix of Power Max plus dicamba plus a group 15 herbicide at two rates.	100%	
3	The original objective was to evaluate on one species, one herbicide containing a group 15 herbicide (Harness) plus another group 15 herbicide (Warrant), on one species; instead, a high rate of a group 15 herbicide (54%) was evaluated. This high rate was used to duplicate the two herbicides together and was conducted on three species not one. This accomplished the same purpose as the original objective of understanding the impact of a common pre-emergent (group 15) on increasing injury with the post-products.	100% +	
4	Evaluate the growth and residual herbicide(s) on foliar samples collected from the five nursery sites involved in this project for each of the three species pre- and post- study. This is done to determine the current scope of the issue with background levels. Objective 3 was exceeded with 37 samples submitted and 9 herbicides tested pre-study (Table 1) and 20 samples submitted for 7 herbicides tested post study (Table 1). This extra sampling gave a broader perspective of what herbicide residue existed as background levels pre- and post- production, but the pre-study took more budget than originally planned. 9 of 37 were positive for herbicide residue pre-study for 5 of the 9 herbicides tested. 9 of the 20 post-study tested positive for 7 of the 7 herbicides tested. These results indicate growers still have not learned that growing near row crops is dangerous for nursery stock.	100% +	
5	Evaluate growth rate at the five nursery sites for the three species of non-applied trees to determine normal growth rates and mortality rates with and without current nursery herbicide spray programs. This will allow for determinations of whether current nursery weed-control programs are adding to drift injury or reducing such potential. Further, to the original objective, we also evaluated growth for the three species applied with Roundup Power Max, Xtendi-Max, Power Max +, Xtendi-Max, and Power Max + Xtendi-Max + Pennant Magnum (group 15 herbicide) to determine which herbicide or combination impacts growth more severely by species.	100% ++	

## ACCOMPLISHMENTS

List your accomplishments for the project's period of performance, including the impact they had on the project's beneficiaries, and indicate how these accomplishments assist in the fulfillment of your project's objective(s), outcome(s), and/or indicator(s).

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Glyphosate is not rapidly metabolized in the plant (Shaner et al., 2014). Equating slower metabolism to higher residues, explains our finding that the largest residues detected in all, but one species/ treatments used (i.e., Fig. 8) was	Exceeding Objective 1 and 5 and providing needed information in the industry to enhance competitiveness of nursery crops (Outcome 3, indicator 1a), (Outcome 4, indicator 2, 3, 4),

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	for glyphosate. Applied alone it had the highest residue 3 times, in <i>Tilia</i> and <i>Syringa</i> at 54% drift, and 18% for <i>Acer</i> . Applied with Dicamba, glyphosate residues were highest five times (Fig. 5-6, 10, and 11-12). Glyphosate at rates of 6-18% combined with dicamba seem to slow metabolism further versus the glyphosate alone. However, at a rate of 54% drift, in <i>Tilia</i> and <i>Syringa</i> , combining with dicamba makes no further metabolism reduction.	(Outcome 5, indicator 6 and 8) and (Outcome 8, indicator 5).
2	Intuitively, it might be expected that higher residue would mean higher injury, but this is not the case with glyphosate. Potentially high residues mean slow metabolism for glyphosate and thus less injury. In five cases (Fig. 5, 8, 9,10 and,11) glyphosate applied alone had no impact on growth measured as caliper over the season, even though glyphosate had the highest residue on 3 of the five cases cited above (Fig. 5, 8, 9,10 and,11). In only one case was caliper growth reduction highest with glyphosate (Fig. 12- <i>Syringa</i> 18%) over the entire study. Therefore, the impact of dicamba is more severe than glyphosate on tree growth.	Exceeding Objective 1 and 5 and providing needed information in the industry to enhance competitiveness of nursery crops (Outcome 3, indicator 1a), (Outcome 4, indicator 2, 3, 4), (Outcome 5, indicator 6 and 8) and (Outcome 8, indicator 5).
3	In terms of phytotoxicity rating, glyphosate caused no commercially unacceptable injury in four cases (Fig. 5, 8, 9, and 11) and in the remaining five cases provided less injury than dicamba or 2-way and 3-way combinations.	Exceeding Objective 1 and 5 and providing needed information in the industry to enhance competitiveness of nursery crops (Outcome 3, indicator 1a), (Outcome 4, indicator 2, 3, 4), (Outcome 5, indicator 6 and 8) and (Outcome 8, indicator 5).
4	Dicamba is metabolized faster in tolerant crops (Shaner et al., 2014); therefore, we would expect to see higher residues with less injury, the same as we saw with glyphosate. In four cases, dicamba residues when applied alone were higher (Fig. 5, 10, 12 and 13) than in the 2- or 3-way combinations; however, in two of these, (Fig. 12 and 13) the combo injury was similar to dicamba alone.	Exceeding Objective 2, 3 and 5 and providing needed information in the industry to enhance competitiveness of nursery crops (Outcome 3, indicator 1a), (Outcome 4, indicator 2, 3, 4), (Outcome 5, indicator 6 and 8) and (Outcome 8, indicator 5).
	Again, as stated in glyphosate summary 2, dicamba had more impact on growth than glyphosate except Fig. 12, but dicamba residues, applied alone were always lower than glyphosate residues applied alone except Fig. 5 and 13 (3-way). Dicamba in a 2-way with glyphosate or in a 3-way with glyphosate and pennant caused more growth reduction versus dicamba alone in all but three cases (Fig. 9, 12 and 13). In those three cases, injury with the combo was no greater than with dicamba alone. Glyphosate only caused the most reduction in caliper when applied at 18% on <i>Syringa</i> (Fig. 12).	Exceeding Objective 2,3 and 5 and providing needed information in the industry to enhance competitiveness of nursery crops (Outcome 3, indicator 1a), (Outcome 4, indicator 2, 3,4), (Outcome 5, indicator 6 and 8) and (Outcome 8, indicator 5).
	37 analyte tests were conducted pre-study (see Table 1) and 20 post-study (Table 1). In the 37 pre-study nine different herbicides were tested. Nine of 37 were positive and with five 5 of the	Exceeding Objective 4 and providing needed information in the industry to enhance competitiveness of nursery crops (Outcome 3, indicator 1a), (Outcome 4, indicator 2, 3, 4),

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	nine i.e., dicamba, indaziflam, clopyralid, glyphosate or 2,4-D. In the 20 post-study, seven herbicides were analyzed, and 9 of 20 were positive for seven of seven tested i.e., Glyphosate, pendimethalin, atrazine, dimethamid, clopyralid, MCPP or glufosinate (Table 2).	(Outcome 5, indicator 6 and 8) and (Outcome 8, indicator 5).

## CHALLENGES AND DEVELOPMENTS

*Provide any challenges to the completion of your project or any positive developments outside of the project's original intent that you experienced during this project. Also, provide the corrective actions you took to address these issues. If you did not attain an approved objectives, outcome(s), and/or indicator(s), provide an explanation in the Corrective Actions column.*

#	Challenge or Development	Corrective Action or Project Change
1	<u>Challenge</u> - to meet the objectives of the grant, and the goal of increasing the industries' knowledge of drift susceptibility of major nursery crops and correlating that level of susceptibility to the herbicide being applied, the ppm determinations of those applications, with damage occurrence, symptomology, and progression, some of the original grant methods were changed.	Additional emphasis was placed on the Group 4 herbicides, and group 15 herbicides versus the group 2 herbicide (Atrazine) as group 2 herbicides were not found in the pre-study collections (Table 2).
2	<u>Challenge</u> - Due to increased sampling pre-study but with reduction in sampling due to change in methods as discussed in challenge 1, we still required a moving of budget lines to secure sufficient funds to complete objective 4 (post-study analyzes) and samples collected for the study of objective 1,2 and 3.	Budget changes were requested, and approval was granted to complete objectives 1-5.
3	<u>Challenge</u> - COVID-19 also caused changes regarding in-person training sessions with the staff at the nurseries involved in this project. These were cancelled.	Arrangements were made for a virtual conference by video. Additionally, posters of herbicide modes of action were developed and printed to send to grant site participants, to help explain our results from the grant, during this virtual conference. The virtual conference of course required additional expenses and time to be incurred by Dr. Mathers to facilitate this event and more planning.
4	<u>Challenge</u> - COVID-19 also influenced Dr. Mathers' decision to <i>not</i> fly to Minneapolis for the final collection and evaluations in August 2020. Although, COVID-19 is part of the reason for not flying, driving was always required, in-order to bring back all the spray equipment and chemical supplies that were utilized during this project and that had been stored in Hastings, MN. The decision to drive was also dictated by the need to reduce travel costs to move travel funds to the "other" budget line.	Travel cost were reduced by driving so there was no rental car fee in addition to the airfare. This left more money in the travel budget line to move to the "Other" budget line for sample analyses. Furthermore, a car was rented instead of charging mileage which would have been more expensive.
1	<u>Development</u> - The determination that glyphosate drift is far less destructive on growth of nursery trees versus dicamba or in combination with dicamba is an unexpected	These findings were accomplished by extra reading of current literature and complex summaries of the data collected.

#	Challenge or Development	Corrective Action or Project Change
	outcome of this study. This has been found before in <i>Vitis</i> but not in nursery. Additionally, higher residues do not mean more injury, in fact higher residual with glyphosate and less so with dicamba mean less injury.	

## LESSONS LEARNED

*Provide recommendations or advice that others may use to improve their performance in implementing similar projects.*

This is a project that was highly dependent on expensive analyte testing. In future studies, even more should be set aside for analyte testing, even if this means doing less studies. Additionally, although the contribution of trees was more than generous by Bailey's, it would have been even more revealing to see the impacts of glyphosate and dicamba drift in the second season after applications.

## CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

*Describe your plans for continuing the project (sustainability; capacity building) and/or disseminating the project results.*

I hope to publish this study in a peer-reviewed journal as the results are excellent and much needed at this critical time of increasing drift injuries in nursery stock. Also, further presentations will be done, throughout the US – virtually, to disseminate these results.

## BENEFICIARIES

**Number of project beneficiaries:** .....12,310

## OUTCOME(S) AND INDICATOR(S)/SUB-INDICATOR(S)

*Provide the results of the project outcome(s) and indicator(s) as approved in your application and project proposal. The results of the outcome(s) and indicator(s) will be used to evaluate the performance of the Program on a national level.*

## OUTCOME MEASURE(S)

*Select the Outcome Measure(s) that were approved for your project.*

- ☐ **Outcome 1:** Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2:** Enhance the competitiveness of specialty crops through increased consumption
- ☒ **Outcome 3:** Enhance the competitiveness of specialty crops through increased access
- ☒ **Outcome 4:** Enhance the competitiveness of specialty crops through greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☒ **Outcome 5:** Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6:** Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7:** Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☒ **Outcome 8:** Enhance the competitiveness of specialty crops through enhancing or improving the economy because of specialty crop development

## OUTCOME INDICATOR(S)

*Provide the indicator approved for your project and the related quantifiable result. If you have multiple outcomes and/or indicators, repeat this for each outcome/indicator (add more rows as needed).*

#	Outcome and Indicator	Quantifiable Results
1	Outcome 3, indicator 1a – reach 300 consumers	Two articles about drift were written in the MNLA The Scoop magazine reaching a circulation of 6,000 each time- Reaching 12,000 member readers. Articles taught specific knowledge for MN of the residual rates of glyphosate and dicamba

		herbicide present on nursery foliage in the state, better identification of the traits associated with various levels of dicamba and glyphosate drift rates on nursery stock and associated with residual foliar residual levels on the stock, and knowledge of growth reduction, stock mortality or grading, long-term of drift events on nursery stock.
2	Outcome 3, indicator 1a – reach 300 consumers	Four presentations were conducted to audiences in MN, two were virtual. Two workshops were conducted as part of Northern Green the MNLA industry conference on Jan. 16, 2020. Additionally, 83 attendees returned completed surveys of 165 audience attendees. These survey responses were used to determine the outcome measures. The third was a video conference lasting 3 hr. and reviewing the results of the 2019 season: Herbicide residuals in MN Nurseries and consequences in weed resistance. Liquid Space to Bailey's Nursery. 25 industry members on March 3, 2020. In these three presentations we reached 210 attendees a covered 4 of 5 benefits for Beneficiaries -discovered the scope of the issue of herbicide drift on nursery trees in MN; Learned the relationship of application time to severity of injury and/or death; learned about the level of injury associated with specific foliar residual and/or drift rate(s); and. the importance of drift reduction technologies to be employed when spraying near "sensitive areas." trees. The fourth presentation was on Sustainable weed control strategies via Zoom for Virtual MN Expo BFG Supply. 100 industry members on Aug. 7. In the four talks a total of 310 people were reached.
3	Outcome 4, indicator 2,3 and 4; and Outcome 5, indicator 2.	More than 25 individuals adopted best management practices and technologies resulting in increased yields and seeing reduced use of herbicides/pesticides. According to our survey given to 165 program attendees with a response rate of 50% or 83 respondents, we learned that 83% of respondent had learned at least one new technology from the program, resulting in 72 adoptions of new practices versus the 25 listed in the application and more than 6 new innovations adopted vs the 6 listed in the application.
4	Outcome 4, indicator 2d	Bailey nursery alone has over 1000 acres in production in MN; so, with their adoption of best management practices alone we exceeded this outcome and indicator.
5	Outcome 5, indicator 6	25 attendees to the three-hour zoom video event were the first responders trained in early detection and rapid response to drift. Over 92% of survey respondent are concerned about herbicide residues on their sites; whereas, before this program, they were unaware of the issue.
6	Outcome 5, indicator 8	310 growers/producers gained knowledge of science-based tools vs the 150 indicated in the application.
7	Outcome 8, indicator 5	Most survey respondents indicated they had learned practices that would increase their revenue by \$4,000.00 to \$8,000.00 which would mean a median gain of \$6,000 versus the \$5,000.00 indicated in the grant application.

## DATA COLLECTION

*Explain what data was collected, how it was collected, the evaluation methods used, and how the data was analyzed to derive the quantifiable indicator.*

Raw data collected is transferred to Excel computer files by Dr. Mathers. All samples are labelled and recorded using Word files and Excel. Backups of all data are stored on external drives. Sample submissions are logged by SDAL and email receipts are sent to Dr. Mathers. All SDAL results are composed and sent as emails and hard copies to Dr. Mathers by SDAL. Dr. Mathers maintains detailed files of hardcopies of SDAL reports and electronic copies. All costs and invoices are also maintained as hard copies in a ledger kept by Mathers Environmental Sciences Services. All digital photos are kept on computer hard drive and backup drive(s).

## FEDERAL PROJECT EXPENDITURES

### EXPENDITURES

MDA approved moving \$2500 from Travel & \$2,860.10 from contractual to Other for more tests- on 7/6/20- less Travel could be conducted during COVID pandemic, and more chemical analysis of samples was needed to accomplish better results for the objectives of this project.

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	\$4,820.00	\$4,820.00
Fringe Benefits	\$1,397.00	\$1,397.00
Travel	\$8,700.00	\$7,795.83
Equipment	NA	NA
Supplies	NA	NA
Contractual	\$62,122.90	\$62,413.94
Other	\$22,960.10	\$23,573.23
<b>Direct Costs Sub-Total</b>	<b>\$100,000.00</b>	<b>\$100,000.00</b>
<b>Indirect Costs</b>		
<b>Total Federal Costs</b>	<b>\$100,000.00</b>	<b>\$100,000.00</b>

### PROGRAM INCOME (IF APPLICABLE)

Source/Nature (i.e., registration fees)	Amount Approved in Budget	Actual Amount Earned
1. N/A		
<b>Total Program Income Earned</b>	<b>N/A</b>	<b>N/A</b>

#### Use of Program Income

*Describe how the earned program income was used to further the objectives of this project.*

N/A

## ADDITIONAL INFORMATION

*Provide additional information available (i.e., publications, websites, photographs) that is not applicable to any of the prior sections.*

*See pages below*

**Table 1.** Soil levels and foliar levels pre- and post- study are presented. Phytotoxicity ratings are placed after the farm name in brackets ex. (3) and are based on a 0-10 scale, where 10 is dead and  $\leq 3$  is considered commercially acceptable. None of the herbicides listed (except for indaziflam) are registered on any nursery species for the over-the-top (OTT) applications; however, all are all known contributors to drift events onto nursery stock from row crop production. (-) represents no analyte test conducted; ND = conducted but non-detected. All samples that were collected were analyzed. Analyte testing was conducted by South Dakota Agricultural Laboratories (SDAL) results are presented in parts per billion (ppb) all pre-study samples were collected May 30, 2019 and post-study Sept. 2 and 3, 2020.

Species	Nursery / Farm	Pre-study foliar ppb Dicamba	Pre-study foliar ppb Atrazine	Pre-study foliar ppb Indazif	Pre-study foliar ppb Clopyralid	Pre-study foliar ppb 2,4-D	Pre-study foliar ppb Glyphosate	Pre-study soil ppb Atrazine	Pre-study soil ppb Indaziflam	Pre-study soil ppb Glyphosate
<i>Tilia cordata</i> 'Greenspire'	Bailey's Joan Rd. Farm (0.9)	2.82	ND	< 5.0	-	-	ND	-	-	52.4
<i>Tilia cordata</i> 'Greenspire'	Bachman's Farm S-6(4)	ND	-	-	ND	ND	ND	-	-	61.8
<i>Acer freemanii</i> 'Jeffersred'	Bailey's Brown Farm (1)	<1.0	-	Post = <5	-	-	ND	-	-	-
<i>Syringa reticulata</i> 'Ivory Silk'	Bailey's O'Connor Farm (3)	ND	ND	ND	20.3	2.69	ND	ND	ND	-
<i>Syringa reticulata</i> 'Snowdance'	Bailey's O'Connor Farm (3)							ND	ND	
<i>Betula populifolia</i> 'Whitespire'	Bachman's Farm 1 (4)	ND	-	-	ND	ND	ND	-	-	-
<i>Betula platyphylla</i> 'Parkland Pillar'	Bailey's Nicolai Ave. (7)	ND	-	-	ND	ND				
<i>Quercus rubra</i>	Bachman's Farm 2 (4)	ND	-	-	ND	4.1	ND	ND	< 5.0	-
<i>Malus</i> "Honeycrisp"	Bachman's	-	-	Post = <5						
		Post - study foliar ppb Dicam	Post-study foliar ppb Clopyralid	Post-study foliar ppb 2,4-D	Post-study foliar ppb Glyph	Post-study foliar ppb Glufosinate		Post-study foliar ppb dimethamid		
<i>Tilia cordata</i> 'Greenspire'										



<i>Tilia cordata</i> 'Greenspire'						
<i>Acer freemanii</i> 'Jeffersred'	ND	ND	ND	ND		
<i>Syringa reticulata</i> 'Ivory Silk'						
<i>Syringa reticulata</i> 'Snowdance'	ND	626 .0	ND			745
	Soil- 1.81	Soil - 247			MCPP <5	
<i>Betula populifolia</i> 'Whitespire'						
<i>Betula platyphylla</i> 'Parkland Pillar'	ND	ND	ND	ND	53.0	
<i>Quercus rubra</i>						
<i>Malus "Honeycrisp"</i>	ND	ND	ND			

**Table 2.** Three species studied are listed with the chemicals applied and their respective rates to simulate drift, with phytotoxicity ratings collected at initiation on June 1, 2019 or pre-study and 3 days after treatment (3 DAT), June 4, 2019, 6 weeks after treatment (6 WAT), July 20, 2019 and 14 WAT (August 30, 2019). The study was conducted at three nursery locations: *Tilia cordata* 'Greenspire' is located at Bailey's County Rd 61 and Joan Ave., (County 89), Hastings, MN; *Acer freemanii* 'Jeffersred' is located at Bailey's Brown Farm at 180 St. E. (one block off Northfield Blvd) or 17625 County Rd 47 (main entrance), Hastings, MN; *Syringa reticulata* 'Ivory Silk' is located at Bailey's O'Connell Farm, 4211, 170<sup>th</sup> St, Rosemont, MN. Analyte testing results are presented for Glyphosate, Dicamba, Dicamba (metabolite – DCSA) and Pennant Magnum according to their respective treatments, in parts per million (PPM). More about the herbicides used is found in the footnotes of Table 2. Analyte testing was conducted by South Dakota Agricultural Laboratories (SDAL). Phytotoxicity is based on a 0-10 scale, where 10 is dead and ≤ 3 is considered commercially acceptable. None of the herbicides listed are registered for the species; however, all are all known contributors to drift events in nursery production from row crop production. (-) represents no analyte test conducted; ND = non-detected; PM= PowerMax, PM1=6%, PM2=18%, PM3=54%; X=XtendiMax, X1=6%, X2=18%, X3=36%; P= Pennant Magnum, P3=54%; DCSA = metabolite of dicamba. All samples that were collected were analyzed. Some samples were not collected as we knew that there was a lack of budget for all analyte tests to be conducted = (lob). The control was untreated.

Species	Treatment	Rate	Start Rating	3 DAT Rating	3 DAT ppm Foliar ppm	6 WAT Rating	6WAT ppm foliar	14WAT Rating	14WAT ppm foliar
<i>Tilia cordata</i> 'Greenspire'	Roundup Power Max® (32 oz/ac)	6%	0	0	PM1=7.7	4.7	PM1=ND	4	PM1=ND
		18%	0.5	2.3	PM2=17.4	6.8	PM2=0.102	5.8	PM2=ND
		54%	0.3	5	PM3=144	6.7	PM3=1.79	6.5	PM3=ND
	XtendiMax® with Vapor-Grip Technology (44 oz/ac)	6%	1.3	4.5	X1=12.4 DCSA=0	5.5	X1=0.182	5.25	X1=0.03
		18%	1	5.8	X2=3.14 DCSA=0	7.5	X2=1.25	7.5	-
		36%	2.3	6.5	X3=33.4 DCSA=0.13	8.5	X3=3.02	8.25	-
	PowerMax + XtendiMax	6% +6%	0.8	4.9	PM1=16.6 X1=5.77 DCSA=0	6.8	PM1=ND X1=3.55 DCSA=0	6.25	PM1=ND X1=0.033
		18 +18 %	1.5	6.8	PM2=60.5 X2=15.4 DCSA=0	9	PM2=0.184 X2=11.7	8.75	PM2=ND
	PM3 + Xtendima	54% +	1.3	7	PM3=36.6 X2=13.2	9.3	PM3=ND X2=0.405	8.75	PM3=ND

	x2 + Pennant3 (32 oz/ac)	18% + 54%			P3=0.402 DCSA=0				
	Control		0.3	0.6	-	2.1		2	X1=0.001
	Average		0.9						
Acer freemanii 'Jeffersred'	Roundup Power Max® (32 oz/ac)	6%	0	1.3	PM1=2.68	6	PM1=0.379	5.5	0.264
		18%	0	1.8	PM2=37.3	6	PM2=0.216	5.25	-
		54%	0.3	2.8	PM3=65.3	6.5	PM3=0.487	6.25	-
	XtendiMax® with Vapor-Grip Technology (44 oz/ac)	6%	0.5	2.8	X1=2.360 DCSA=0	7	X1=0.125 DCSA=0	6.25	X1=0.0347 DCSA=0
		18%	0.5	3.8	X2=8.26 DCSA=0	7.3	X2=0.226	6.75	-
		36%	1.3	6	X3=25.3 DCSA=0.954	7.5	X3=0.675	6.5	-
	PowerMax + XtendiMax	6% + 6%	0.5	3.8	PM1=3.84 X1=2.14 DCSA=0	7	PM1= 0 X1= 0.148 DCSA=0	6.75	PM1=ND X1=0.0302
		18 + 18 %	1.0	5.8	PM2=26. X2=9.6 DCSA=0.173	8	PM2=0.212 X2=0.777 DCSA=0	7.5	-
	PM + XtendiMax + Pennant (32 oz/ac)	54% + 18% + 54%	1.3	7.5	PM3=20.1 X2=8.19 P3=0.0680 DCSA=0.177	8	PM3=0.224 X2=0.587 DCSA=0 P=0.0643	8	-
	Vanquish (16 oz/ac)	100 %	0.8	6.8	V=87.9 DCSA 0.244	7.3	Not done	7.25	V=0.0683 2,4-D=0.00484
	Control		0.1	0	N/A	0		0	-
	Average		0.6						
Syringa reticulata 'Ivory Silk'	Roundup Power Max® (32 oz/ac)	6%	0.1	0	PM1=12.0	6	PM1=0.0806	7.5	PM1=ND
		18%	0.25	1.8	PM2=8.148	6.5	PM2=ND	6	PM3=ND
		54%	0	2.0	PM3=52.0	6	PM3=2.09	6.5	PM3=ND

	<b>XtendiMax® with Vapor-Grip Technology (44 oz/ac)</b>	<b>6%</b>	0.5	2.3	X1=8.85 DCSA = 0	6.5	X1=0.11	7.5	X1=ND
		<b>18%</b>	1.1	6.4	X2=31.4 DCSA=0.162	6.4	X2=0.275	8.5	-
		<b>36%</b>	1.0	6.3	X3=18.5	6.8	X3=0.834	6.75	-
	<b>PowerMax 1+ XtendiMax 1</b>	<b>6% +6%</b>	0.3	3.8	PM1=14.9 X1=8.36	7.3	PM1=0.131 X1=0.254 DCSA=0.092	8	PM1=ND
		<b>18 +18 %</b>	1.8	7.3	PM2=36.7 X2=12.3	7.5	PM2=0.124 X2=0.943 DCSA=0.373	8	PM2=ND
	<b>PM3 + Xtendimax2 + Pennant3 (32 oz/ac)</b>	<b>54% + 18% + 54%</b>	1.0	6.5	PM3=27.9 X2=11.15	7.3	PM3=ND X2=1.25	8.5	PM3=ND
	<b>Vanquish (16 oz/ac)</b>	<b>100 %</b>	0.8	3.8		6		8.25	V=0.0104
	<b>Control</b>	<b>100 %</b>	0		ND	0	X1=0.00123	0	ND
	<b>Average</b>		0.6						

**Footnotes:**

- **Roundup Power Max®** (EPA Reg. No. 524-549) [Glyphosate, N-(phosphonomethyl) glycine as a potassium salt 48.7% (4.5 pounds a.e. per gallon) (Bayer Crop Science, Research Triangle, NC). This herbicide is in the EPSP synthase inhibitor WSSA group 9 MoA and chemical family Organophosphorus. The standard rate of glyphosate is 0.75 pounds of a.e. per acre (Armstrong and Lancaster, 2012). A rate of 32 oz/ac was used in this study at 6, 18 and 54% for drift rates.
- **XtendiMax®** (EPA Reg. No. 524-617) [Diglycolamine salt of dicamba (3,6-dichloro-o-anisic acid)] 42.8% (Acid equivalent (a.e.): 29% dicamba – 2.9 pounds acid per gallon)) (Bayer Crop Science, Research Triangle, NC). XtendiMax® is in the synthetic auxin WSSA group 4 mode of action (MoA) and chemical family Benzoic acids. A rate of 44 oz/ac was used in this study at 6, 18 and 36% for drift rates.
- **Pennant Magnum** (EPA reg No. 100-950) S-metolachlor 83.7% (Syngenta Crop Protection, LLC, Greensboro, NC). A rate of 2.0 pt./ac was used only in a three-way combination with glyphosate and dicamba at a 54% drift.
- **Combination applications:** Power Max + XtendiMax were conducted at 6% each, 18% each, and a three-way with Pennant Magnum at 54% glyphosate, 18% dicamba and 54% Pennant.

**Table 3.** *Tilia cordata* ‘Greenspire’ found at Bailey Nurseries, Inc., County Rd 62 and 89, Hastings, MN for two dates of evaluation pre-study or initiation (May 30, 2019) and 14 weeks after treatment (WAT), August 30, 2019. Calipers (mm) and heights (cm) are presented plus the change in caliper and height from initiation to 14 WAT. No SPAD readings were collected for *Tilia cordata* ‘Greenspire’. Each data point represents the mean of four replicates. Treatments with the same letters indicate no significant difference with LSD 0.05. PM means Power Max; X means XtendiMax. Numbers (1, 2 or 3) following PM indicate at 6%, 18% or 54%, respectively. Numbers (1, 2 or 3) following X indicate 6, 18 or 36%. Treatment 9 was PM 54% + X 18% + Pennant Magnum (32 oz). Treatment 10 was an untreated control.

Treatment	Caliper (mm) May 30, 2019	Caliper August 30, 2019	Change Caliper 05 to 08, 2019	Height (cm) May 30, 2019	Height August 30, 2019	Delta Height (cm) 05 to 08, 2019
<b>PM1</b>	15.93a	26.42	<b>10.49</b>	74.81	102.75	<b>27.94</b>
<b>PM2</b>	16.04a	22.46	<b>6.42</b>	59.56	81.13	<b>21.56</b>
<b>PM3</b>	14.88a	20.85	<b>5.97</b>	63.56	68.00	<b>4.44</b>
<b>X1</b>	13.40a	20.61	<b>7.22</b>	58.81	71.00	<b>12.19</b>
<b>X2</b>	13.89a	16.21	<b>2.32</b>	54.00a	55.25	<b>1.25</b>
<b>X3</b>	13.88a	14.95	<b>1.07</b>	53.06a	52.75	<b>-0.31</b>
<b>PM1 + X1</b>	16.64a	22.17	<b>5.52</b>	68.75	81.50	<b>12.75</b>
<b>PM2 + X2</b>	17.10a	14.33	<b>0.6</b>	74.88	57.25	<b>-0.8</b>
<b>PM3 + X2 + Pennant</b>	15.90a	11.65a	<b>0.3a</b>	68.63	47.63	<b>-1.3</b>
<b>Control</b>	15.47a	25.45	<b>9.99</b>	69.06	112.25	<b>43.2</b>
<b>Min</b>	13.4	11.65	<b>-4.25</b>	53.06	47.63	<b>-1.3</b>
<b>Max</b>	17.1	26.42	<b>10.49</b>	74.88	112.25	<b>43.2</b>
<b>Average</b>	15.4	20.49	<b>5.1</b>	64.512	72.951	<b>8.438</b>
<b>% reduction min vs control</b>			<b>97%</b>			<b>100%</b>

y = All measures are indicated in their respective units.

x = Measures followed by the same letters are not significantly different from each other based on Lsmeans ( $\alpha = 0.05$ ).

i = Delta HT and delta caliper represents the change from the end of the trial to the start or 14WAT before.

w =  $\Delta$  represents delta.

**Table 4.** *Acer freemanii* 'Jeffersred' located at Bailey's Brown Farm at 180 St. E. (one block off Northfield Blvd) or 17625 County Rd 47 (main entrance), Hastings, MN for two dates of evaluation pre-study or initiation (May 30, 2019) and 14 weeks after treatment (WAT), August 30, 2019. Calipers (mm) and heights (cm) are presented plus the change in caliper and height from initiation to 14 WAT. SPAD readings for *Acer freemanii* 'Jeffersred' are above critical which is >25. Each data point represents the mean of four replicates. Treatments with the same letters indicate no significant difference with LSD 0.05. Numbers (1, 2 or 3) following PM indicate at 6%, 18% or 54%, respectively. Numbers (1, 2 or 3) following X indicate 6, 18 or 36%. Treatment 9 was PM 54% + X 18% + Pennant Magnum (32 oz). Treatment 10 was an untreated control.

Treatment	Caliper (mm) May 30, 2019	Caliper August 30, 2019	Change Caliper 05 to 08, 2019	Height (cm) May 30, 2019	Height August 30, 2019	Delta Height (cm) 05 to 08, 2019	Av SPAD 14 WAT
PM1	27.4a	35.4c	8.0b	99a	118bc	19c	35.3
PM2	25.7a	34.9bc	9.2b	95a	118bc	23cd	35.8
PM3	27.0a	34.8bc	7.8b	97a	103.5a	6.5ab	33.4
X1	26.4a	35.8c	9.4b	100a	113.5b	13.5b	27.1
X2	26.1a	33.9b	7.8b	96.5a	106.5a	10b	31.1
X3	26.0a	34.3bc	8.3b	98.25a	103a	4.8a	38.1*
PM1 + X1	27.0a	35.2b	8.2b	95.5a	106a	10.5b	30.7
PM2 + X2	25.6a	33.8b	8.2b	95.75a	103a	7.3ab	36.3
PM3 + X2 + Pennant	25.8a	32.2a	6.4a	96.25a	105.8a	9.5ab	38.2*
Vanquish	26.4a	33.0ab	6.6a	96.25a	103a	6.8ab	37.6*
Control	25.8a	34.2bc	8.4b	97.25a	122c	24.8d	29.2
Min	25.6	32.2	6.4	95.0	103	4.75	27.1
Max	27.4	35.8	9.4	100.0	122	24.75	38.2
Average	26.3	34.3	8.0	97.0	109.3	12.3	33.9
% reduction min vs control			24%			81%	

y = All measures are indicated in their respective units.

x = Measures followed by the same letters are not significantly different from each other based on Lsmeans ( $\alpha = 0.05$ ).

i = Delta HT and delta caliper represents the change from the end of the trial to the start or 14WAT before.

w =  $\Delta$  represents delta.

**Table 5.** *Syringa reticulata* 'Ivory Silk' located at Bailey's O'Connell Farm, 4211, 170<sup>th</sup> St, Rosemont, MN., for two dates of evaluation (pre-study or initiation, (May 30, 2019) and 14 weeks after treatment (WAT), August 30, 2019. Calipers (mm) and heights (cm) are presented plus the change in caliper and height from initiation to 14 WAT. SPAD readings for *Acer freemanii* 'Jeffersred' are above critical which is >25. Each data point represents the mean of four replicates. Treatments with the same letters indicate no significant difference with LSD 0.05. PM means Power Max; X means XtendiMax. Numbers (1, 2 or 3) following PM indicate at 6%, 18% or 54%, respectively. Numbers (1, 2 or 3) following X indicate 6, 18 or 36%. Treatment 9 was PM 54% + X 18% + Pennant Magnum (32 oz). Treatment 10 was an untreated control.

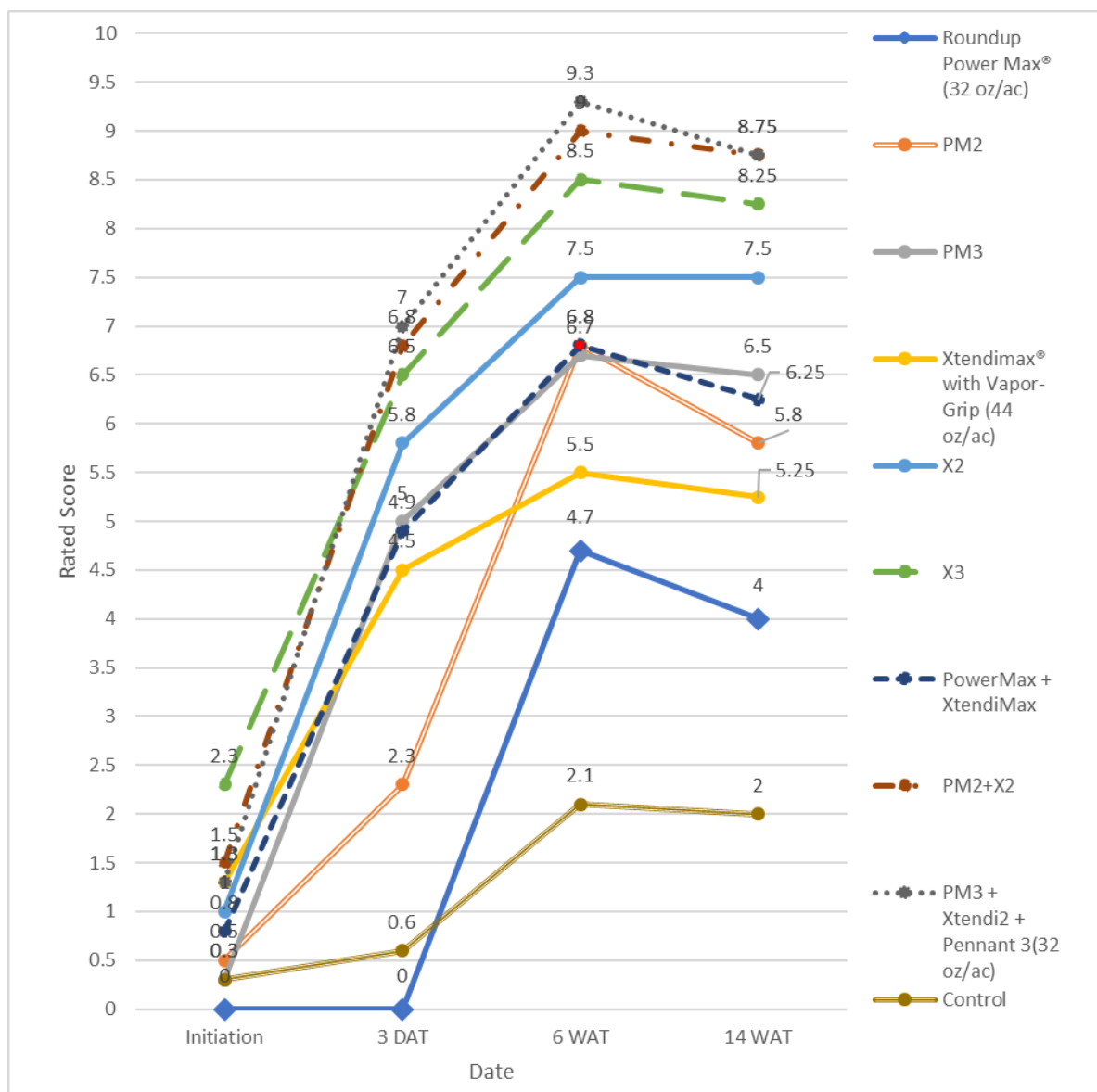
Treatment	Caliper (mm) May 30, 2019	Caliper August 30, 2019	Change Caliper 05 to 08, 2019	Height (cm) May 30, 2019	Height August 30, 2019	Delta Height (cm) 05 to 08, 2019	Av SPAD 14 WAT
PM1	18.69bc	26.22	7.52	79.25	85	5.75	64.2
PM2	18.63bc	23.97	5.35	78.75	96.25	17.5	56.3
PM3	17.44b	24.67	7.23	66.25	78.75	12.5	63.8
X1	18.33bc	25.75	7.42	80.75	92	11.25	58.0
X2	18.57bc	24.82	6.26	79.75	86	6.25	69.9
X3	17.54b	21.9	4.36	74.5	84.25	9.75	73.2*
PM1 + X1	15.85a	21.31	5.47	73.63	83.5	9.88	55.8
PM2 + X2	19.63c	25.76	6.13	83.5	87.75	4.25	65.4
PM3 + X2 + Pennant	18.37bc	23.44	5.08	73	73.25	0.3	70.7*
Vanquish	15.18a	20.9	5.73	66.5	72.5	6.0	70.4*
Control	17.37b	24.6	7.23	63	89.5	26.5	54.1
Min	15.18	20.9	4.36	63	72.5	0.25	54.1
Max	19.63	26.22	7.52	83.5	96.25	26.5	73.2
Average	17.78	23.94	6.16	74.44	84.43	9.99	64.2
% reduction min vs control			39%			99%	

y = All measures are indicated in their respective units.

x = Measures followed by the same letters are not significantly different from each other based on Lsmeans ( $\alpha = 0.05$ ).

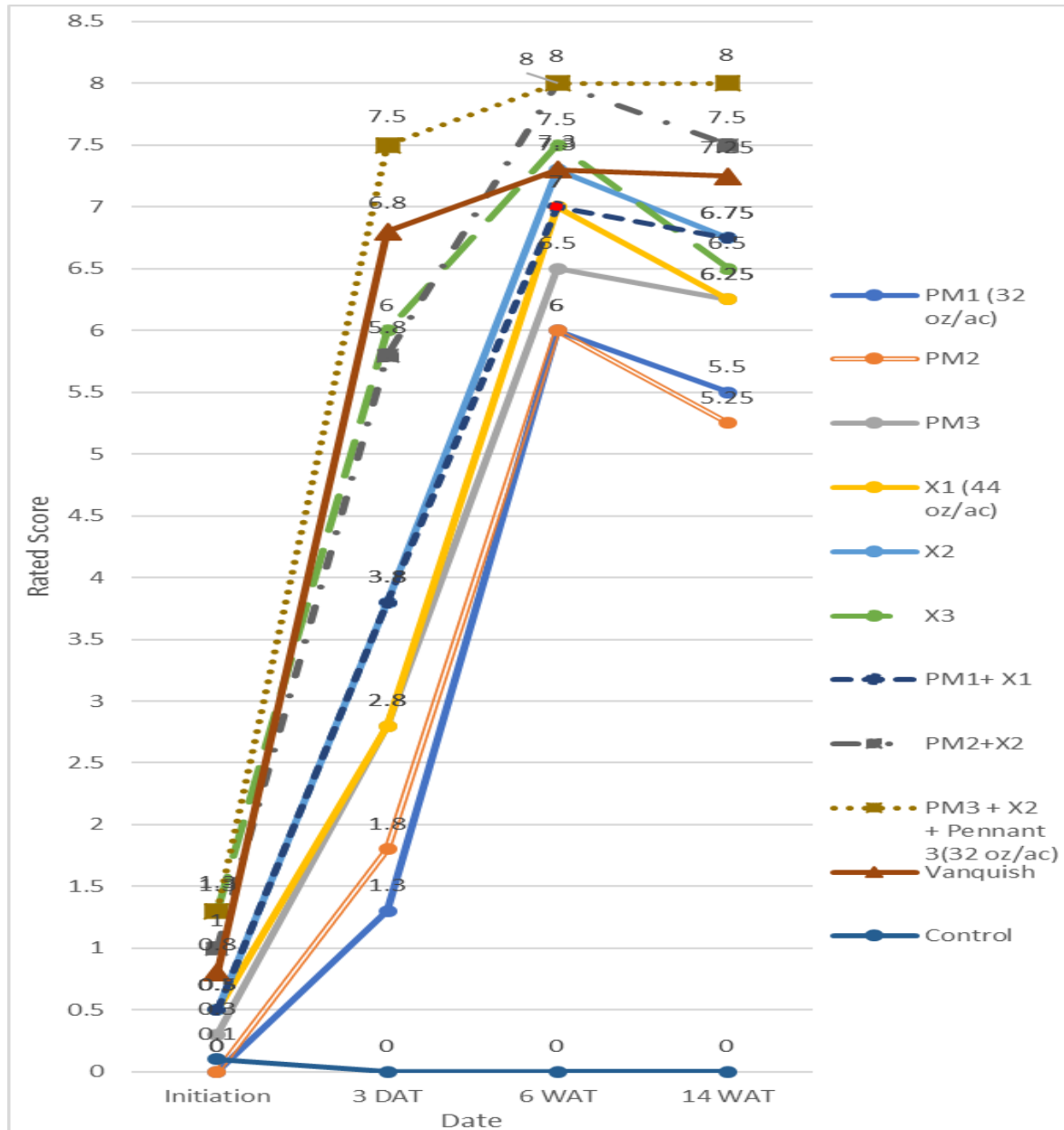
i = Delta HT and delta caliper represents the change from the end of the trial to the start or 14WAT before.

w =  $\Delta$  represents delta.

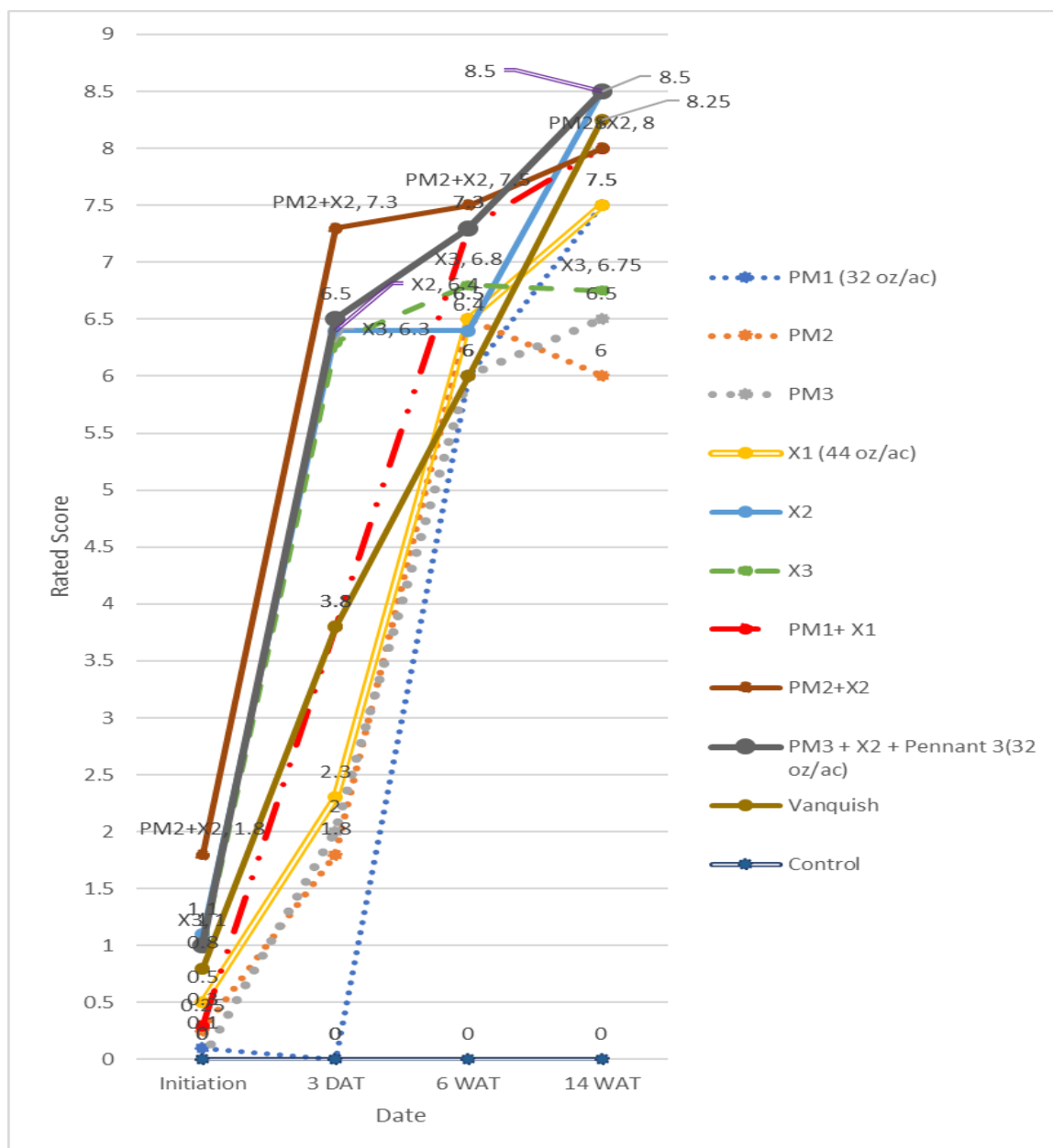


**Figure 1.** Rated score data for *Tilia cordata* 'Greenspire' found at Bailey Nurseries, Inc., County Rd 62 and 89, Hastings, MN for four dates of evaluation (pre-study or initiation, June 1, 2019, 3 days after treatment (3 DAT), and 6 weeks after treatment (6 WAT) and 14 WAT. Ten treatments are listed in the legend to the left of the graph. PM means Power Max; X means XtendiMax. Numbers (1, 2 or 3) following PM indicate at 6%, 18% or 54%, respectively. Numbers (1, 2 or 3) following X indicate 6, 18 or 36%. Treatment 9 was PM 54% + X 18% + Pennant Magnum (32 oz). Treatment 10 was an untreated control. Ratings are for phytotoxicity (0-10), where 10 represented plant death, 0 represented no injury, and  $\leq 3$  is considered commercially acceptable.





**Figure 2.** Rated score data for *Acer freemanii* 'Jeffersred' located at Bailey's Brown Farm at 180 St. E. (one block off Northfield Blvd) or 17625 County Rd 47 (main entrance), Hastings, MN for four dates of evaluation (pre-study or initiation, June 1, 2019; 3 days after treatment (3 DAT); 6 weeks after treatment (6 WAT) and 14 WAT. Eleven treatments are listed in the legend to the left of the graph. PM means Power Max; X means XtendiMax. Numbers (1, 2 or 3) following X indicate 6, 18 or 36%. Treatment 9 was PM 54% + X 18% + Pennant Magnum (32 oz). Treatment 10 was an untreated control. Ratings are for phytotoxicity (0-10), where 10 represented plant death, 0 represented no injury, and  $\leq 3$  is considered commercially acceptable.



**Figure 3.** Rated score data for *Syringa reticulata* 'Ivory Silk' located at Bailey's O'Connell Farm, 4211, 170<sup>th</sup> St, Rosemont, MN., for three dates of evaluation (pre-study or initiation, June 1, 2019, 3 days after treatment (3 DAT), and 6 weeks after treatment (6 WAT). Eleven treatments are listed in the legend to the left of the graph. PM means Power Max; X means XtendiMax. Numbers (1, 2 or 3) following X indicate 6, 18 or 36%. Treatment 9 was PM 54% + X 18% + Pennant Magnum (32 oz). Treatment 10 was an untreated control. Ratings are for phytotoxicity (0-10), where 10 represented plant death, 0 represented no injury, and  $\leq 3$  is considered commercially acceptable



PM3 + Xtendi2 + Pennant 3(32 oz/ac)	6.6d	6.2c	5.8c	6.2
Vanquish	--	5.5c	4.7b	5.1
Control	1.3a	0.0a	0.0a	0.4a
Min	1.3	0.0	0.0	0.4
Max	6.6	6.2	6.2	6.2
Average	4.6	4.2	4.3	4.4

**ii) Delta caliper (mm)**

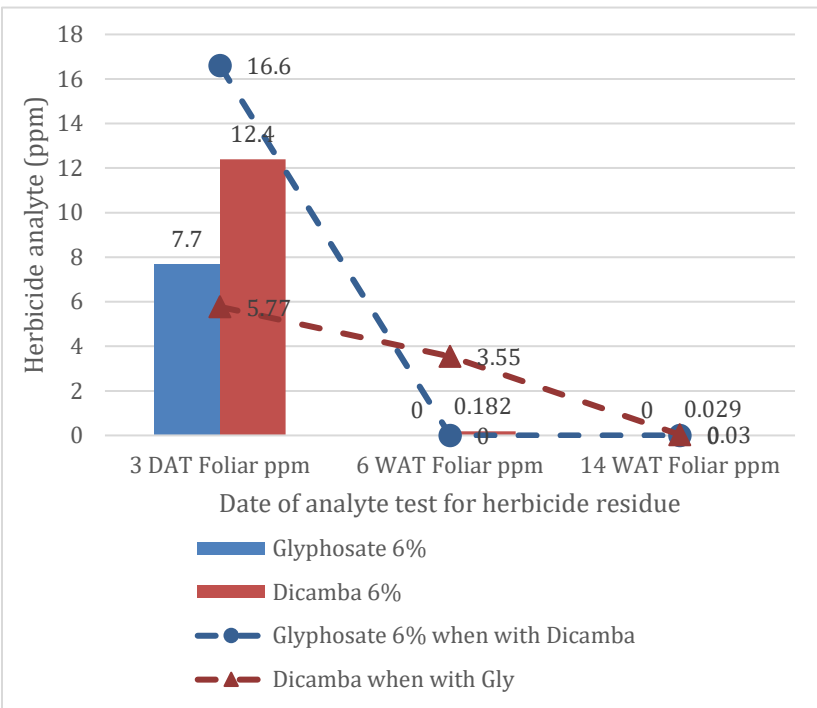
Treatment	<i>Tilia cordata</i> 'Greenspire'	<i>Acer freemanii</i> 'Jeffersred'	<i>Syringa reticulata</i> 'Ivory Silk'	Average
Roundup Power Max® (32 oz/ac)	10.5	8	7.5	8.7
PM2	6.4	9.2	5.3	7.0
PM3	6	7.8	7.2	7.0
XtendiMax® with Vapor-Grip (44 oz/ac)	7.2	9.4	7.4	8.0
X2	2.3	7.8	6.3	5.5
X3	1.1	8.3	4.4	4.6
PowerMax + XtendiMax	5.5	8.2	5.5	6.4
PM2+X2	0.6	8.2	6.1	5.0
PM3 + Xtendi2 + Pennant 3(32 oz/ac)	0.3	6.4	5.1	3.9
Vanquish	--	6.6	5.7	6.2
Control	10	8.4	7.2	8.5
Min	0.3	6.4	4.4	3.9
% reduction vs control	<b>97%</b>	<b>24%</b>	<b>39%</b>	

**iii) Delta height (cm)**

Treatment	<i>Tilia cordata</i> 'Greenspire'	<i>Acer freemanii</i> 'Jeffersred'	<i>Syringa reticulata</i> 'Ivory Silk'	Average
Roundup Power Max® (32 oz/ac)	27.9	19	5.8	17.6
PM2	21.6	23	17.5	20.7
PM3	4.4	6.5	12.5	7.8
XtendiMax® with Vapor-Grip (44 oz/ac)	12.2	13.5	11.3	12.3
X2	1.3	10	6.3	5.9
X3	-0.3	4.8	9.8	4.8
PowerMax + XtendiMax	12.8	10.5	9.9	11.1
PM2+X2	-0.8	7.3	4.3	3.6
PM3 + Xtendi2 + Pennant 3(32 oz/ac)	-1.3	9.5	0.3	2.8
Vanquish		6.8	6	6.4
Control	43.2	24.8	26.5	31.5
Min	-1.3	4.8	0.3	2.8
% reduction vs control	100%	81%	99%	

iv) Change in GI <sup>t</sup>			
Treatment	<i>Tilia cordata</i> 'Greenspire'	<i>Acer freemanii</i> 'Jeffersred'	<i>Syringa reticulata</i> 'Ivory Silk'
Roundup Power Max <sup>®</sup> (32 oz/ac)	343,92.6	202,599.9	13,714.27
PM2	4,762.9	156,897	6261.0
PM3	2,735.5	117,279.80	1096.1
XtendiMax <sup>®</sup> with Vapor-Grip (44 oz/ac)	17,000	156,232.90	5140.76
X2	2,446.4	129,952.60	4979.8
X3	2,135.9	99,971	49.49.1
PowerMax + XtendiMax	40,315.3	138,209.50	5352.98
PM2+X2	3,116.5	106,029	2783.4
PM3 + Xtendi2 + Pennant 3(32 oz/ac)	1,245.6	79,960.30	372.03
Vanquish	-	82,980	1796.75
Control	126,998.7	235,177.70	11999.17
Min	1,245.8	79,960.3	372.03
% reduction vs control	99%	97%	97%

y = All measures are indicated in their respective units and the calculated Growth Index measures are in cm<sup>3</sup>.  
i = Delta HT represents the change on height end of the trial from the start or 14WAT  
t = GI represents Growth index (in<sup>3</sup>) and was calculated as  $GI = \pi (Ht)(r^2)$ , where Ht. (in) was the starting or final height, respectively, r was half of the average of W1+W2 (two perpendicular measurements taken of plant diameter (in)) and Pi was "π". The GI provides a volume measure of the plant as a cone which helps with quality determinations not necessarily evident by heights and widths alone or by visual observations. In this case the cone is inverted so that the base or radius measures are for the top and the plant narrows to the base (ground).

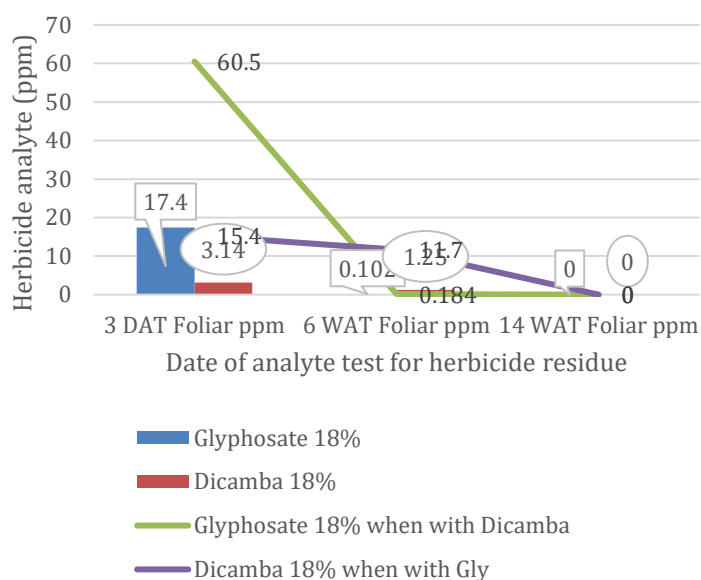


**Fig. 5. *Tilia cordata*** 'Greenspire' at Bailey's, Joan Ave, Hastings, MN farm for 6% drift rate of Roundup Power Max (32 oz/ac rate) (glyphosate) and XtendiMax (44 oz/ac) dicamba, and the combination of Power Max + XtendiMax both at 6% drift rate. Showing glyphosate residue was increased with the addition of dicamba in the combined application, but not dicamba. Glyphosate at 6% drift provided no reduction in caliper over the study period (May – October 2019). Dicamba, however, did significantly reduce caliper and the combination further reduce caliper vs the dicamba





alone. Rated score (0-10) with  $\leq 3$  being commercially acceptable and 10 being dead, became unacceptable with dicamba 6%, but not glyphosate. Rated score also was increased further by combining the two actives. The combination increased the duration of analyte residue. Data next page:

	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
<b>Glyphosate 6%</b>	7.7	0	0	10.49a	2.2b
<b>Dicamba 6%</b>	12.4	0.182	0.029	7.22b	4.1c
<b>Glyphosate 6% when with Dicamba</b>	16.6	0	0	5.52c	4.7c
<b>Dicamba when with Glyphosate</b>	5.77	3.55	0.03	5.52c	4.7c
<b>Control</b>	0	0	0	9.99a	0.7a

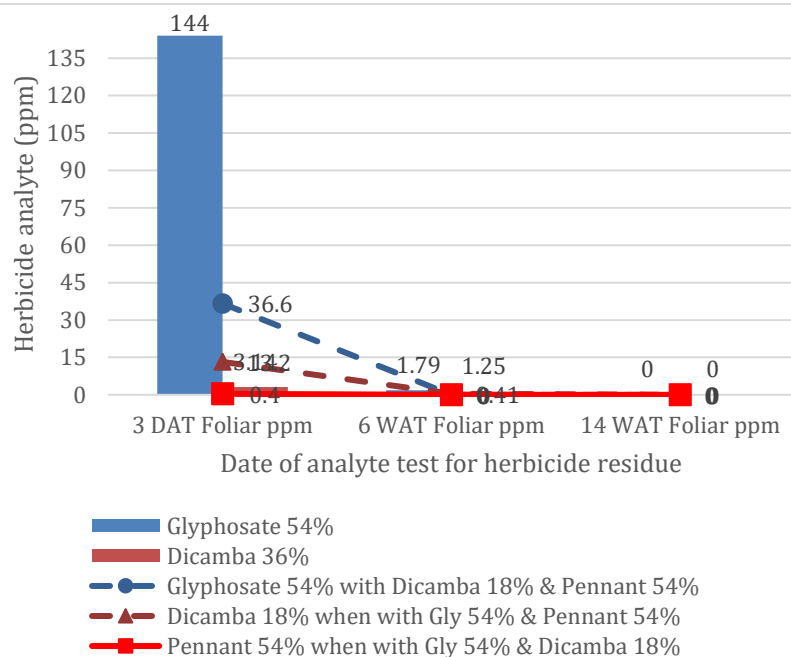
**Fig. 5. data**



**Fig. 6.** *Tilia cordata* 'Greenspire' at Bailey's, Joan Ave, Hastings, MN farm for 18% drift rate of Roundup Power Max (32 oz/ac rate) (glyphosate) and XtendiMax (44 oz/ac) dicamba, and the combination of Power Max + XtendiMax both at 18% drift rate. Showing glyphosate residue was increased with the addition of dicamba in the combined application as was dicamba. This diverged from the 6% rate (Fig. 5) as only glyphosate increased at a 6% drift rate. Glyphosate at 18% drift provided a reduction in




	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
 <b>Glyphosate 18%</b>	17.4	0.0102	0	6.42b	3.9b
 <b>Dicamba 18%</b>	3.14	1.25	0	2.32c	5.5c
 <b>Glyphosate 18% when with Dicamba</b>	60.5	0.184	0	0.6d	6.5d
 <b>Dicamba 18% when with Glyphosate</b>	15.4	11.7	0	0.6d	6.5d
<b>Control</b>	0	0	0	9.99a	1.0a

caliper over the study period (May – October 2019) vs the control, which varied from the 6% drift with no reduction. Dicamba, further reduced caliper vs. glyphosate and the combination further reduce caliper vs the dicamba alone. Rated score (0-10) with  $\leq 3$  being commercially acceptable and 10 being dead, became unacceptable with glyphosate 6%, and dicamba. Rated score also was increased further by combining the two actives.

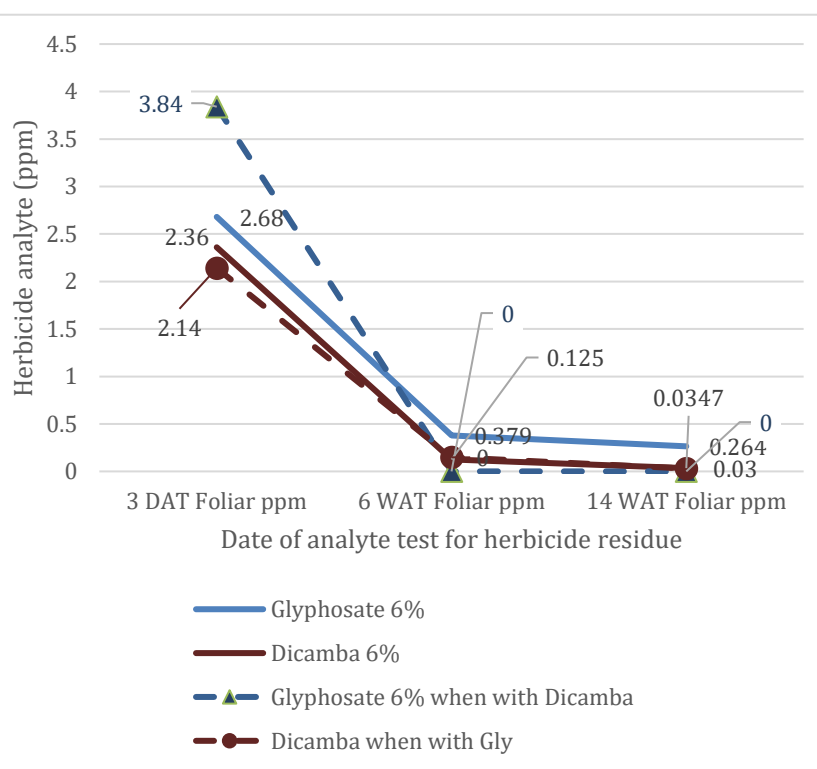


**Fig. 7.** *Tilia cordata* 'Greenspire' at Bailey's, Joan Ave, Hastings, MN farm for 54% drift rate of Roundup Power Max (32 oz/ac rate) (glyphosate) and XtendiMax (44 oz/ac) dicamba, and the combination of Power Max 54%+ XtendiMax 18%+ Pennant 54%. Showing glyphosate residue was highest applied alone and decreased when added to dicamba. Dicamba residue, however, was higher in the combo vs applied alone. Glyphosate

at 54% drift did decreased caliper growth versus the control; however, the dicamba alone impact and in the 3-way combination reduced growth further. The rated score increased significantly with glyphosate 54% and further with dicamba 36%, with the 3-way providing no further increase in phytotoxicity rating.

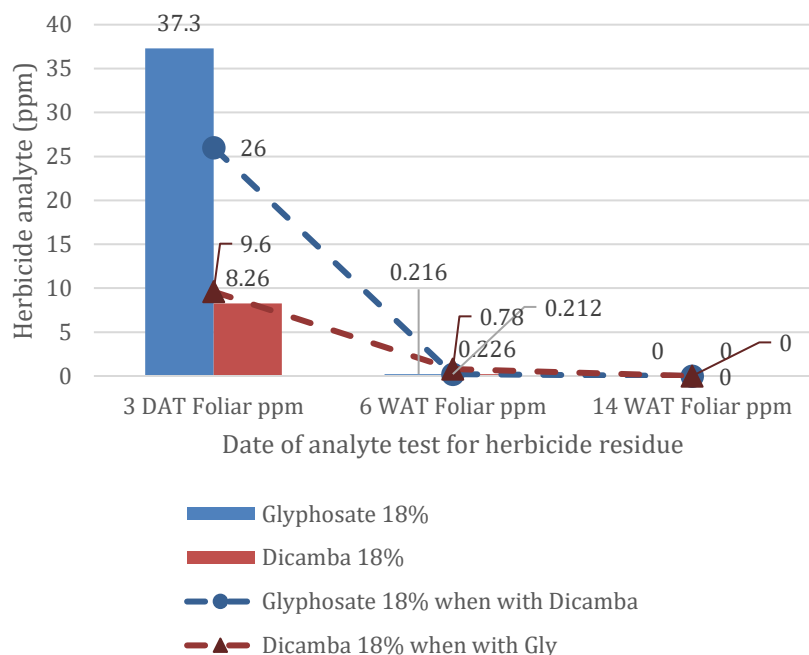
	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
<b>Glyphosate 54%</b>	144	1.79	0	5.97b	4.6b
<b>Dicamba 36%</b>	3.14	1.25	0	1.07c	6.4c
<b>Glyphosate 54% when with Dicamba</b> 	36.6	0	0	0.3d	6.6c
<b>Dicamba 18% when with Glyphosate</b> 	13.2	0.41	0	0.3d	6.6c
<b>Pennant 54% when with Glyphosate 54% + Dicamba 18%</b> 	0.402	0	0	0.3d	6.6c
<b>Control</b>	0	0	0	9.99a	1.3a





**Fig. 8.** *Acer X freemanii* 'Jeffersred' at Bailey's, Brown Farm, Hastings, MN farm for 6% drift rate of Roundup Power Max (32 oz/ac rate) (glyphosate) and XtendiMax (44 oz/ac) dicamba, and the combination of Power Max + XtendiMax both at 6% drift rate. Showing glyphosate residue was increased with the addition of dicamba in the combined application, but dicamba residue was not increased in the combination versus dicamba alone. Glyphosate and dicamba at 6% and the combination of the two had no impact of caliper growth in *Acer* versus the control. Glyphosate at 6% only marginally increased injury, as a rated score, over commercially unacceptable. Dicamba, however, did significantly increase phytotoxicity as a rated score versus glyphosate and the control. The injury was not significantly increased by combining the two actives versus dicamba alone.

	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta caliper (mm)	Av. Rating of 4 Dates
<b>Glyphosate 6%</b>	2.68	0.379	0.26	8.0a	3.2b
<b>Dicamba 6%</b>	2.36	0.125	0.035	9.4+	4.1c
<b>Glyphosate 6% when with Dicamba</b>	3.84	0	0	8.2a	4.5c
<b>Dicamba when with Glyphosate</b>	2.14	0.148	0.03	8.2a	4.5c
<b>Control</b>	0	0	0	8.4a	0.4a

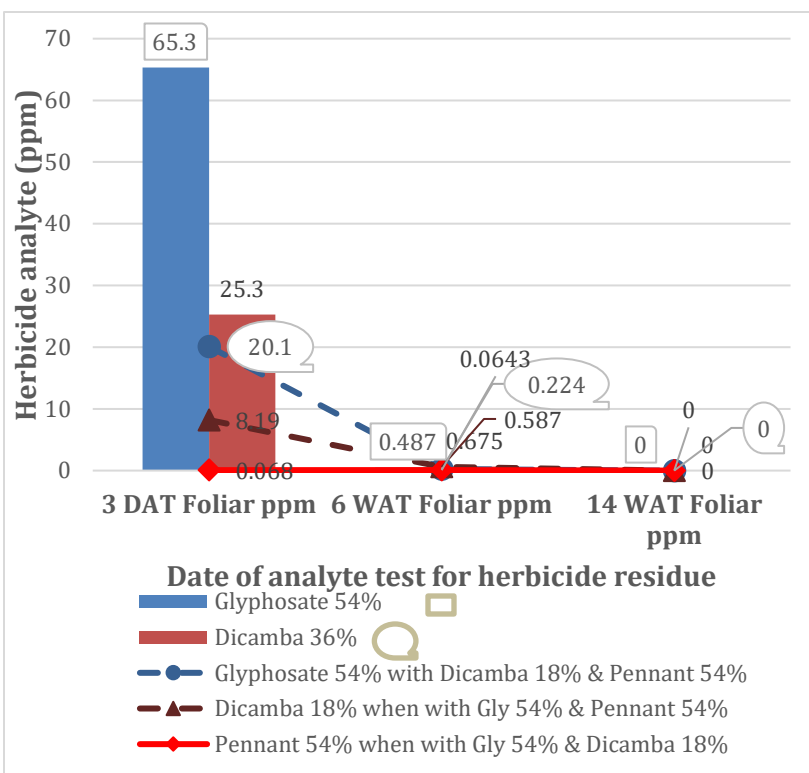


**Figure 9.** *Acer X freemanii* 'Jeffersred' at Bailey's, Brown Farm, Hastings, MN farm for 18% drift rate of Roundup Power Max (32 oz/ac rate)

(glyphosate) and XtendiMax (44 oz/ac) dicamba, and the combination of Power Max + XtendiMax both at 18% drift rate. Showing glyphosate residue was increased with the addition of dicamba as in (Fig. 5 and 6). In the combined application






versus the dicamba applied alone the dicamba residue was increased as in (Fig. 6 and 7). Glyphosate, dicamba at 6%, and the combination of the two had no impact of caliper growth in *Acer* versus the control like *Acer* 6% (Fig.8). Glyphosate at 6% only marginally increased injury, as a rated score, over commercially unacceptable. Dicamba, however, did significantly increase phytotoxicity as a rated score versus glyphosate and the control. Injury was significantly increased by combining the two actives versus dicamba or glyphosate alone. Data only below:

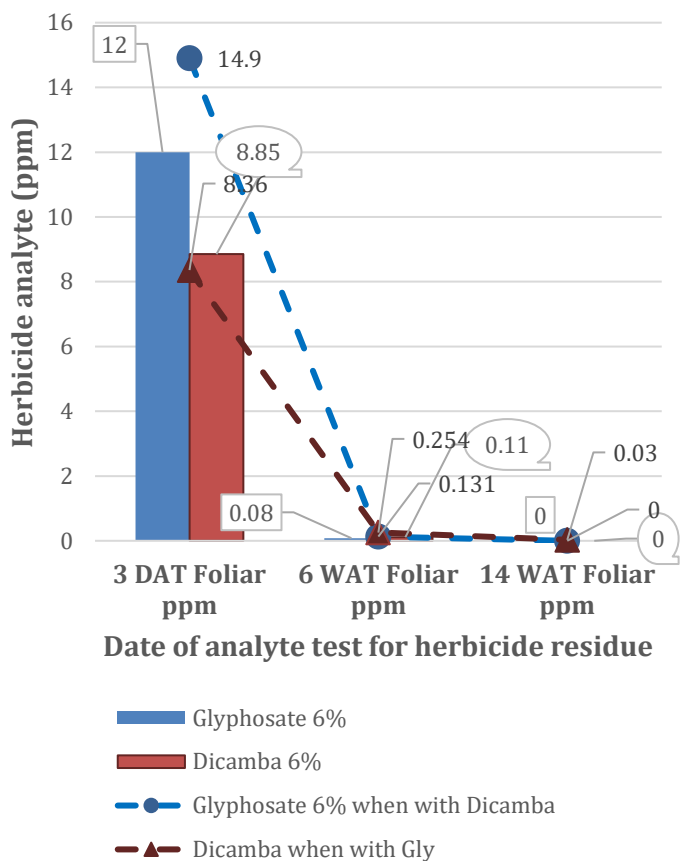
	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
<b>Glyphosate 18%</b>	37.3	0.216	0	9.2+	3.3b
<b>Dicamba 18%</b>	8.26	0.226	0	7.8a	4.6c
<b>Glyphosate 18% when with Dicamba</b>	26.0	0.212	0	8.2a	5.6d
<b>Dicamba 18% when with Glyphosate</b>	9.6	0.78	0	8.2a	5.6d
<b>Control</b>	0	0	0	8.4a	0.5a



**Figure 10.** *Acer X freemanii* 'Jeffersred' at Bailey's, Brown Farm, Hastings, MN farm for 54% drift rate of Roundup Power Max (32 oz/ac rate) (glyphosate) and 36 % drift rate for XtendiMax (44 oz/ac) dicamba, and the combination of Power Max (54%) + XtendiMax (36%) drift rates. Showing glyphosate residue was not increased with the addition of dicamba in the combined application nor was dicamba residue in the combination with glyphosate. Glyphosate, dicamba at 54 and 36%, respectively, and had no impact on reducing caliper growth in *Acer* versus the control but in the **3-way caliper was decreased.**





Glyphosate at 54% increased injury, as a rated score, over commercially unacceptable. Dicamba, further significantly increase phytotoxicity versus glyphosate. The injury was significantly increased in the 3-way versus dicamba and glyphosate.

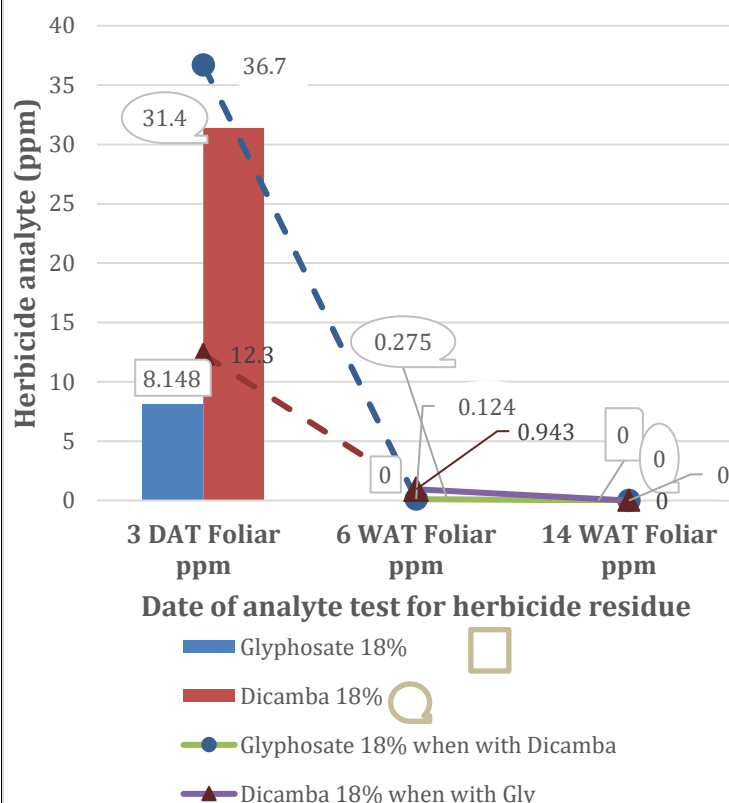
	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
 <b>Glyphosate 54%</b>	65.3	0.487	0	7.8a	4.0b
 <b>Dicamba 36%</b>	25.3	0.675	0	8.3a	5.3c
 <b>Glyphosate 54% when with Dicamba</b>	20.1	0.224	0	6.4b	6.2d
 <b>Dicamba 18% when with Glyphosate</b>	8.19	0.587	0	6.4b	6.2d
 <b>Pennant 54% when with Glyphosate 54% + Dicamba 18%</b>	0.068	0.0643	0	6.4b	6.3d
<b>Control</b>	0	0	0	8.4a	0.96a



**Figure 11.** *Syringa reticulata* 'Ivory Silk' at Bailey's, O'Connell Farm, Hastings, MN for 6% drift rate of Roundup Power Max (32 oz/ac rate) (glyphosate) and XtendiMax (44 oz/ac) dicamba, and the combination of Power Max + XtendiMax both at 6% drift rate. Showing glyphosate residue was increased with the addition of dicamba in the combined application, but not dicamba with the addition of glyphosate. Glyphosate at 6% drift provided no reduction in caliper over the study period (May – October 2019) nor did Dicamba. However, the combination did significantly reduce caliper vs the glyphosate alone but not dicamba alone. Rated score (0-10) with  $\leq 3$  being commercially acceptable and 10 being dead, became unacceptable with dicamba 6%, but only slightly for glyphosate. Rated score was not further increased by combining the

two actives versus dicamba alone.

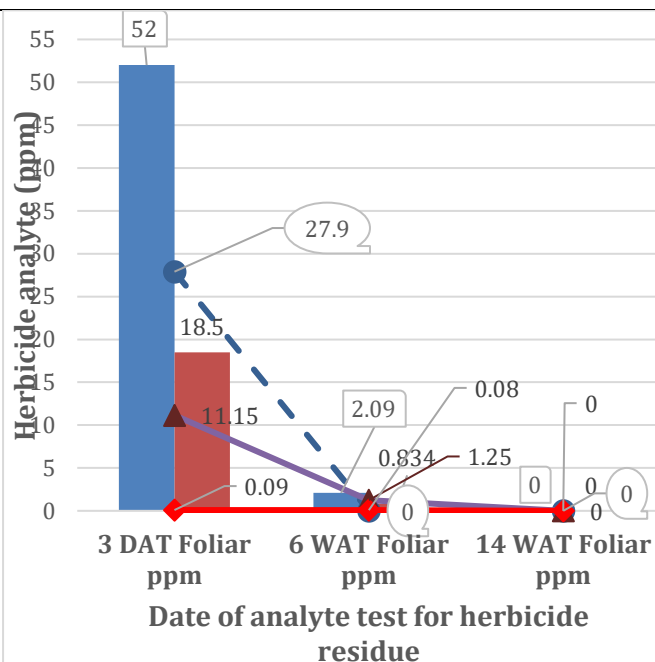
	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
 <b>Glyphosate 6%</b>	12.0	0.0806	0	7.52+	3.4b
 <b>Dicamba 6%</b>	8.85	0.11	0	7.42+	4.2c
 <b>Glyphosate 6% when with Dicamba</b>	14.9	0.131	0	5.47b	4.9c
 <b>Dicamba 6% when with Glyphosate</b>	8.36	0.254	0	5.47b	4.9c
<b>Control</b>	0	0	0	7.23a	0.3a






**Fig. 12.** *Syringa reticulata* 'Ivory Silk' at Bailey's, O'Connell Farm, Hastings, MN for 18% drift rate of Roundup Power Max (32 oz/ac rate) (glyphosate) and XtendiMax (44 oz/ac) dicamba, and the combination of Power Max + XtendiMax both at 18% drift rate. Showing glyphosate residue was increased with the addition of dicamba in the combined application, but not dicamba with the addition of glyphosate was not. Glyphosate at 18% drift provided a reduction in caliper over the study period (May – October 2019) versus the control. A further reduction in caliper vs the glyphosate occurred with dicamba alone. No further reduction in caliper occurred with the combination versus dicamba alone. Rated score (0-10) with  $\leq 3$  being commercially acceptable and 10 being dead, became

unacceptable with glyphosate 18% and further with dicamba 18%. Rated score was further increased by combining the two actives versus dicamba or glyphosate alone.

	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
<b>Glyphosate 18%</b>	8.148	0	0	5.35b	3.6b
<b>Dicamba 18%</b>	31.4	0.275	0	6.26c	5.6c
<b>Glyphosate 18% when with Dicamba</b>	36.7	0.124	0	6.13c	6.2c
<b>Dicamba 18% when with Glyphosate</b>	12.3	0.943	0	6.13c	6.2c
<b>Control</b>	0	0	0	7.23a	1.05a



dicamba 36%. Rated score was not further increased in the 3-way versus dicamba alone.

	3 DAT Foliar ppm	6 WAT Foliar ppm	14 WAT Foliar ppm	Delta Caliper (mm)	Av. Rating of 4 Dates
<b>Glyphosate 54%</b>	52.0	2.09	0	7.23a	3.6b
<b>Dicamba 36%</b>	18.5	0.834	0	4.36b	5.2c
 <b><u>Glyphosate</u> 54% when with Dicamba</b>	27.9	0	0	5.08b	5.8c
 <b><u>Dicamba</u> 18% when with Glyphosate</b>	11.15	1.25	0	5.08b	5.8c
 <b><u>Pennant 54%</u> when with Glyphosate 54% + Dicamba 18%</b>	0.09	0.08	0	5.08b	5.8c
<b>Control</b>	0	0	0	7.23a	0.67a

