Injury to nursery crops from herbicide residues in contaminated irrigation water

NC STATE UNIVERSITY

Linkedin/camila montoya

Camila Montoya[1], Joseph Neal[2], Wesley Everman[1], Travis Gannon[1], Christopher Harlow[2], Diego J. Contreras[1], Eric Jones[1]
[1]Dept of Crop and Soil Sci., [2]Dept of Horticultural Sci., North Carolina State University, Raleigh, North Carolina

Southern IPM Center

Introduction

Container production of nursery crops is an intensive cropping system requiring numerous management inputs including frequent irrigation. Most container nurseries use surface ponds as source water for overhead irrigation and each day apply about 20,000 gallons of water per acre.

Recently, surface ponds at several nurseries in North Carolina were contaminated with herbicides applied to nearby rights of way (ROW) sites resulting in extensive damage and crop losses. Diagnosis of the causes was hampered by limited information on the bioactivity of low concentrations of herbicides in irrigation water. The herbicides suspected in these events included aminocyclopyrachlor, imazapyr, and metsulfuron-methyl. These herbicides are labeled for broad spectrum control of woody and herbaceous weeds in non-crop areas, including ROWs. Aminocyclopyrachlor is a synthetic auxin; imazapyr and metsulfuron-methyl are ALS-inhibitors. Each of these herbicides has the potential to cause significant injury to several nursery crop species (Goodale et al 2016a&b, Marble et al. 2022). However, the concentrations of herbicide contaminants in irrigation water that would injure crops are not known.

Objective and Hypothesis

- The objective of this project was to document crop injury from log-dilutions of aminocyclopyrachlor, imazapyr, and metsulfuron-methyl contaminants in irrigation water.
- Our hypothesis was that some crop injury would be observable at or below the detection limit in water for these herbicides.

Materials and Methods

- The plants
  - Arborvitae (*Thuja* x 'Green Giant'), *Hypericum inodorum* 'Miracle Grandeur', and rose (*Rosa x* 'Knockout Double Red') were selected species because they exhibited significant injury in nurseries and to represent a diversity of plant types. Green beans (*Phaseolus vulgaris*) were included as a readily accessible and easy-to-grow bioassay species.
  - Green beans were seeded in pots that contained hammer milled pine bark substrate. Beans were 4 inches tall at the time of treatment.
  - Hypericum and rose rooted cuttings were potted to 4-L plastic pots using a hammer milled pine bark substrate and grown for 8 weeks to ensure an established root system and vigorous vegetative growth.
  - Arborvitae were well established in 4-L pots and about 50 cm tall with new growth. All were top-dressed with slow-release fertilizer
- Treatments
  - Aminocyclopyrachlor, imazapyr, and metsulfuron methyl
  - Each mixed to dilutions of 0.1X, 1X, 10X and 100X of the detection limits in water (Table 1); 1X = detection limit
  - Applied as a foliar and soil drench, three times over a 10-day period. Irrigation was paused on the days plants were treated. On all other days, pots received 1.5 cm of overhead irrigation.
- Randomized complete block design with 7 replications, except roses for which there were 5 replicates; 1 plant of each species per experimental unit
- Evaluations
  - Plant injury was visually evaluated about on 7-to-10-day intervals using a scale from 0-10 where 0 = healthy plant and 10 = dead plant.
  - Above-ground fresh weights were recorded 6 weeks after initial applications

The experiment about 1 week after the first application

Table 1. Selected herbicides and concentrations applied, as a multiple of the detection limits in water

	Concentration applied (µg/L), as a multiple of the detection limit			
Herbicide	0.1X	1X	10X	100X
Aminocyclopyrachlor	0.1	1	10	100
Imazapyr	0.02	0.2	2	20
Metsulfuron-methyl	0.008	0.008	0.08	0.8

*Detection limits as reported by one widely-used commercial water testing laboratory. For this study, the detection limit was set as the 1X dilution.

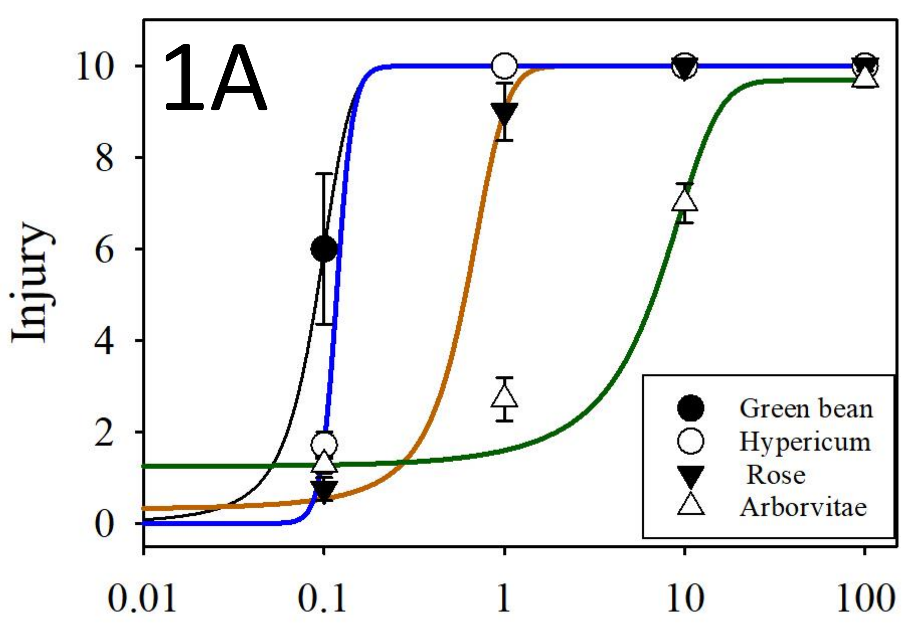


Figure 1A. Injury to green beans (black), hypericum (blue), rose (orange) and arborvitae (green) when irrigated with water contaminated with aminocyclopyrachlor.

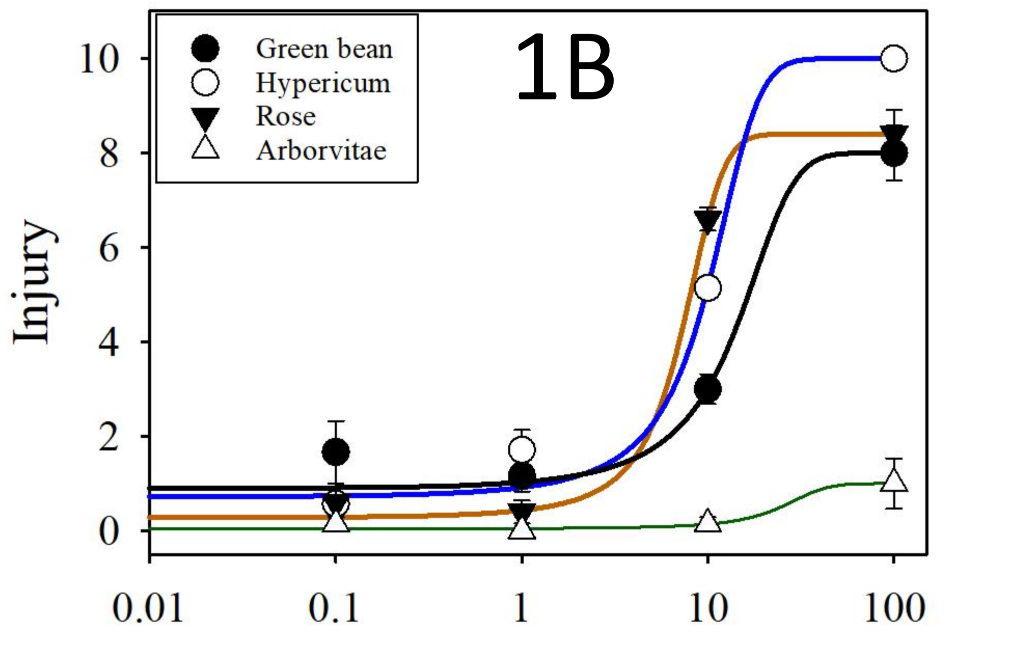


Figure 1B. Injury to green beans (black), hypericum (blue), rose (orange) and arborvitae (green) when irrigated with water contaminated with imazapyr.

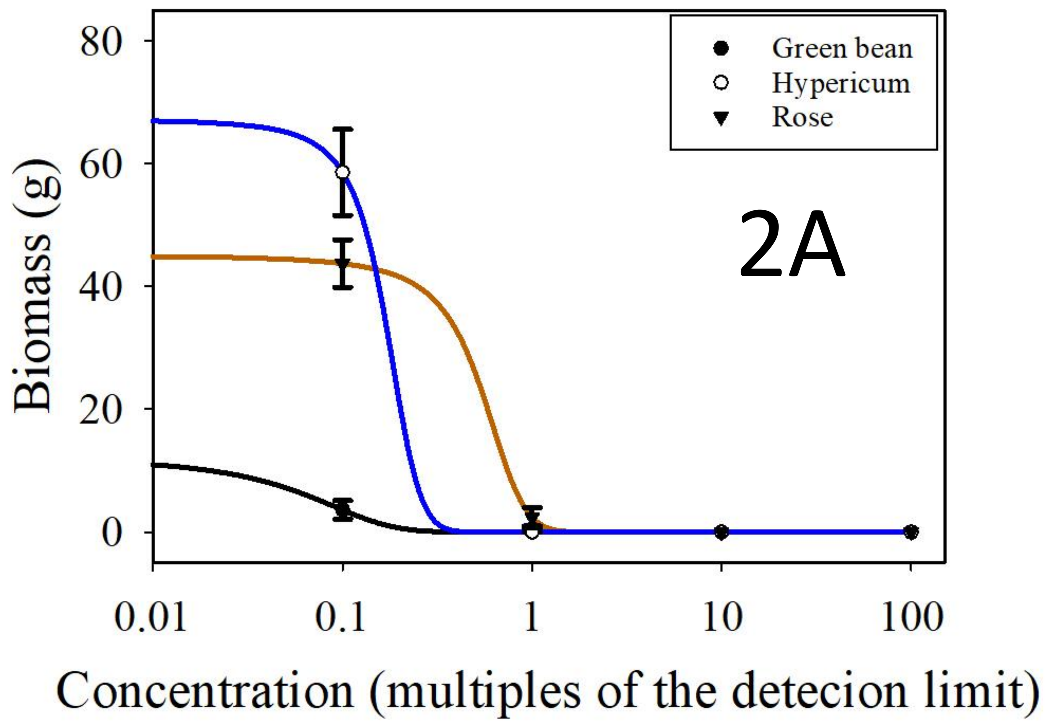


Figure 2A. Fresh weights of green beans (black), hypericum (blue) and rose (orange) after aminocyclopyrachlor treatments. Fresh weights were weighed after fifth evaluation.

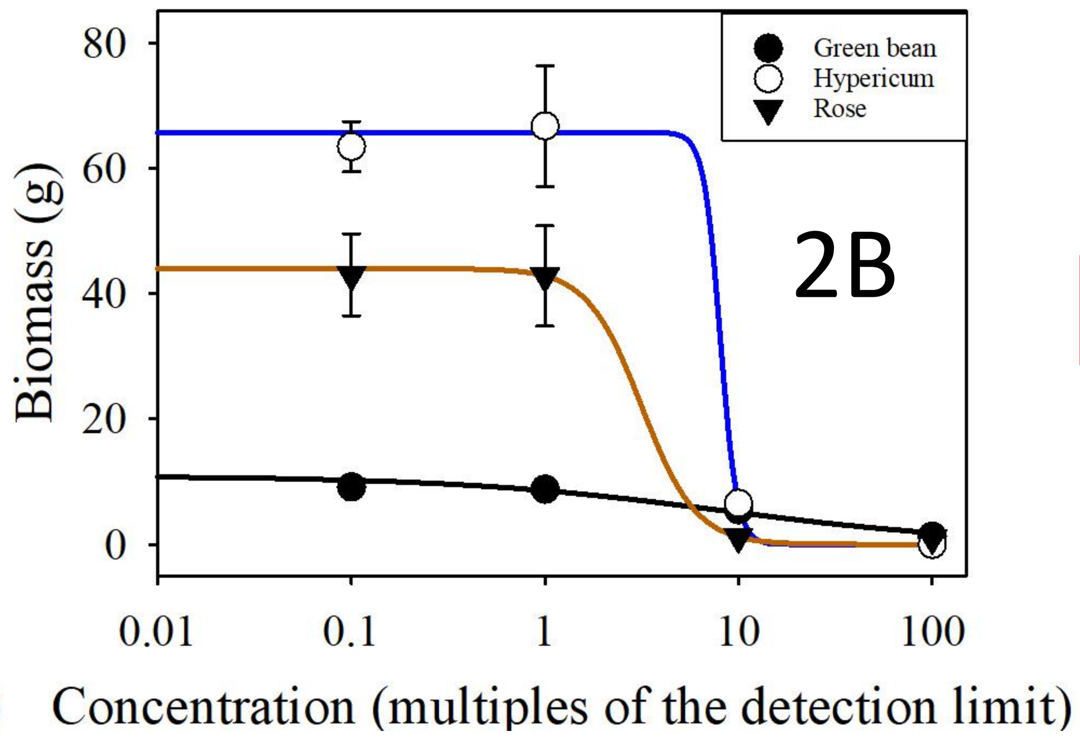
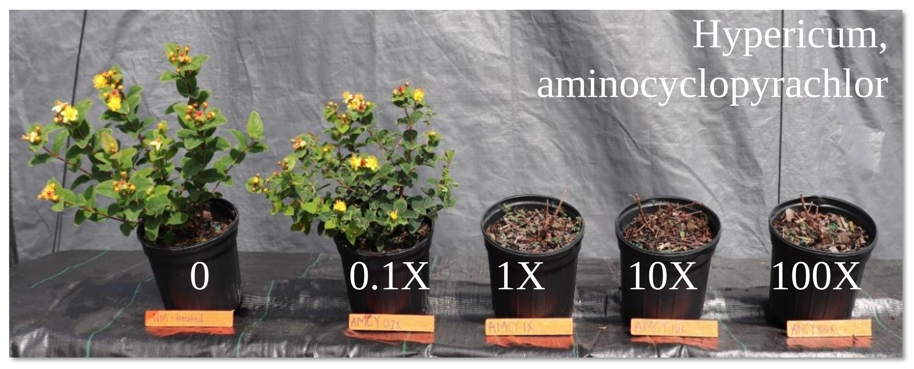
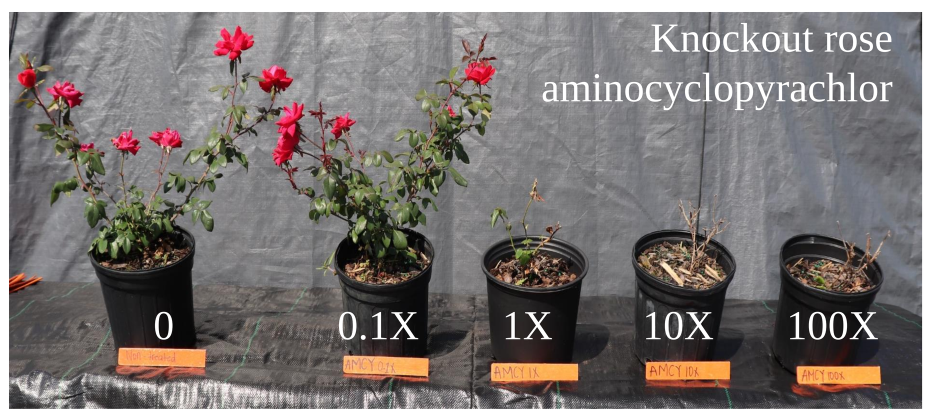


Figure 2B. Fresh weights of green beans (black), hypericums (blue) and roses (orange) after imazapyr treatments. Fresh weights were weighed after fifth evaluation.

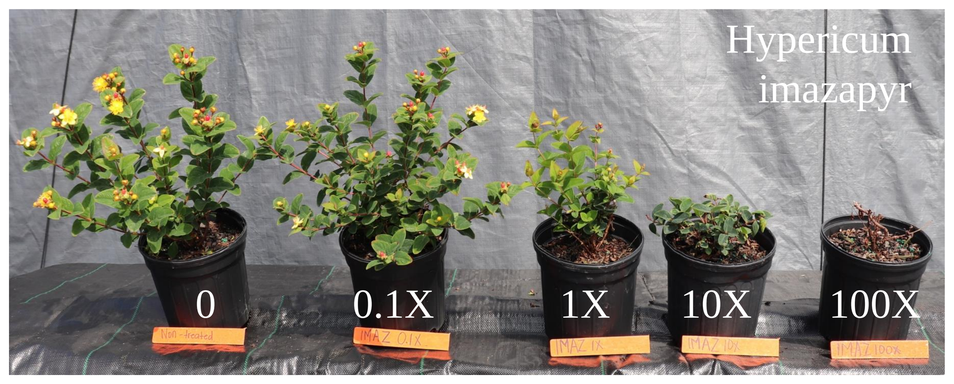
Aminocyclopyrachlor





0 0.1X 1X 10 X

Imazapyr



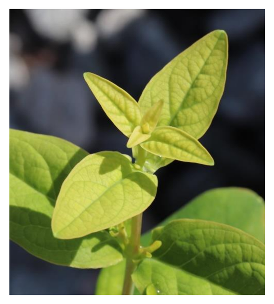
0.1X 1X 10 X 100 X

Results

- Metsulfuron-methyl concentrations up to 0.8 µg/L (100X the detection limit in water) did not injury the bioassay species tested (data not shown).
- Aminocyclopyrachlor caused injury at or below detection limits (Figure 1A , 2A, & photos).
  - Injured hypericum, bean and arborvitae at 0.1 µg/L
  - Minor foliar symptoms on rose at 0.1 µg/L
  - Severe injury or mortality of hypericum, bean and rose at 1 µg/L
  - Caused mortality of arborvitae at 10 µg/L
- Imazapyr caused injury at the detection limit of 0.2 µg/L (Figures 1B, 2B and photos).
  - Stunting of green beans, hypericum and rose were observed starting at 0.2 µg/L
  - Increased severity of injury with increasing concentration
  - Arborvitae was more tolerant of imazapyr. Minor discoloration of growing points at 1X; tip necrosis at 100X.
- Data trends for visual ratings and fresh weights were similar, but visual evaluations detected chlorosis and malformed foliage (as shown below) that were not reflected in fresh weight reductions

Epinasty on rose from 0.1X aminocyclopyrachlor

Tip damage to arborvitae from 0.1X aminocyclopyrachlor



Temporary chlorosis on hypericum caused by 0.1X imazapyr

Conclusions

- Crop injury can occur when irrigation water contains concentrations of aminocyclopyrachlor or imazapyr at or below detection limits.
- Bioassays are more sensitive than current chemical analyses for either aminocyclopyrachlor or imazapyr.
- Metsulfuron-methyl detection limits for laboratory analyses of water samples are sufficiently sensitive to be useful in crop injury diagnostic testing.
- When diagnosing herbicide injury, one must be aware that laboratory testing of irrigation water, while an important tool, may not be a reliable method to identify causal agents or eliminate sources of potential herbicide exposure.

Future Research

The present study had several limitations that may require additional study.

- In this study we applied treatment solutions 3 times, but in container nurseries plants are irrigated daily. How would daily irrigation alter crop responses to very low concentrations or to metsulfuron-methyl?
- What are the bioactive concentrations for metsulfuron-methyl and other non-crop herbicides?
- Right of way herbicides are typically applied in mixtures. Would such mixtures have different crop responses?
- What are the longer-term outcomes for woody perennial crops exposed to low concentrations?
- How do other crops respond; in natural soil systems vs. soilless substrates used herein; drip irrigation vs. overhead?

Acknowledgements

- Project funding was provided by the Southern Region IPM.

References

- Goodale, D, J. Neal, & K. Jennings 2016a. Acetolactate synthase (ALS) inhibitors; herbicide injury fact sheet series https://content.ces.ncsu.edu/acetolactate-synthase-als-inhibitors
- Goodale, D, J. Neal, & K. Jennings 2016b. Synthetic auxin herbicides; herbicide injury fact sheet series https://content.ces.ncsu.edu/synthetic-auxins
- Marble, C. et al. 2022 Metsulfuron-Methyl-Containing Herbicides Potentially Damaging Ornamentals when Applied to turfgrass https://edis.ifas.ufl.edu/publication/FR400