

Does NDVI consistently assess plant response to herbicides?

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Introduction

Visual rating is the most widely used method to assess herbicide injury of plants. However, there is an increasing need for more objective data to supplement visual ratings due to their innate subjectivity. Normalized difference vegetation index (NDVI) has been widely used to assess abiotic and biotic stress on turfgrass such as herbicide injury (Bell et al. 2000; Brewer et al. 2016). Past observations suggest NDVI responses following herbicide injury may be mode-of-action dependent, but more research is needed to test this theory.

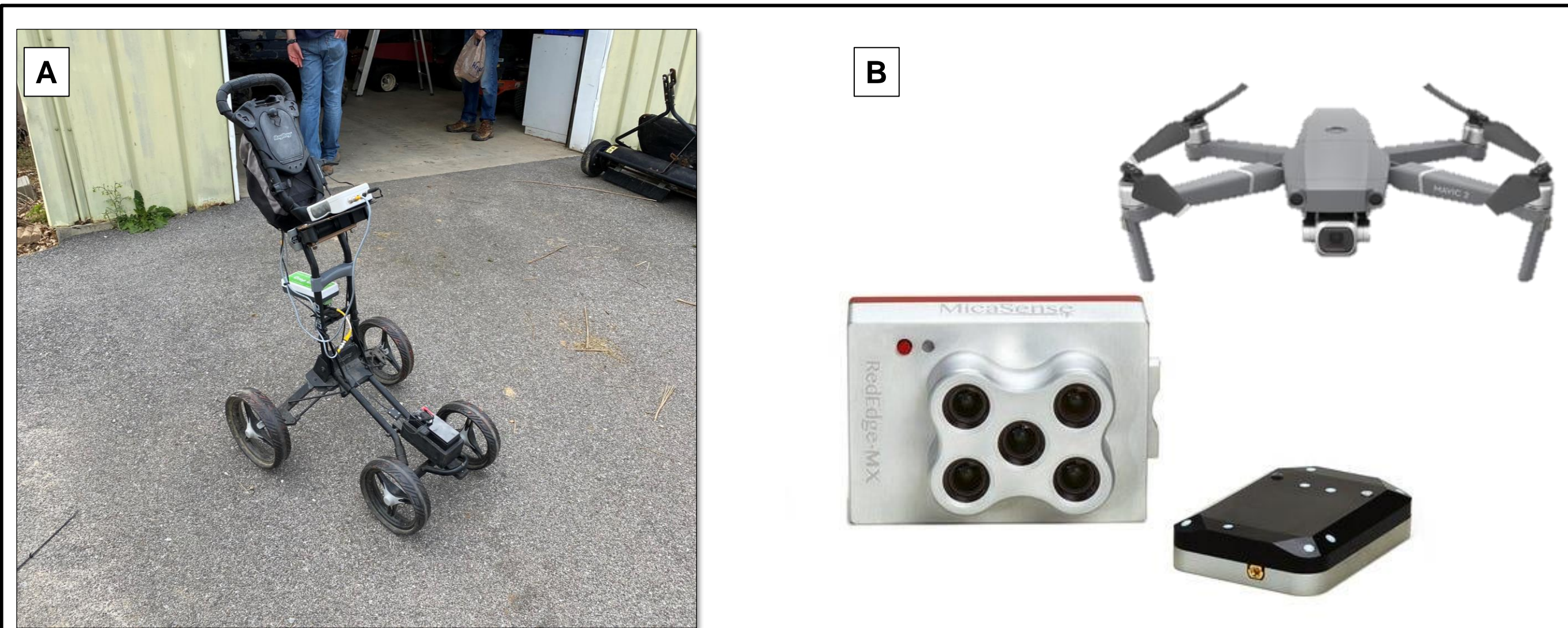


Figure 1. Multispectral sensors (A) Crop Circle ACS-430 (Holland Scientific, Lincoln, NE) that measures red and NIR reflectance value (B) MicaSense RedEdge MX (MicaSense Inc., Seattle, WA) mounted on DJI Mavic 2 Pro (DJI, Shenzhen, China) that collects blue, green, red, red-edge, and near infra-red (NIR) images

Objective

To investigate the relationship between visual rating by a trained observer and NDVI generated from multispectral data assessed by ground or aerial devices on creeping bentgrass injury from herbicides with varying modes of action

Materials and Methods

- 2-year field study (Oct to Nov 2021, May to Jun 2022) at Glade Road Research Facility, Blacksburg, VA
- RCBD design, 4 trials, 4 replications, 13 treatments incl. untreated

Herbicide	Mode of action	Rate – 2021	Rate – 2022
Sulfosulfuron (Certainty) ¹	ALS Inhibitor (WSSA Group 2)	5.6 g ai/ha	5.6 g ai/ha
		11 g ai/ha	11 g ai/ha
		17 g ai/ha	22 g ai/ha
		22 g ai/ha	34 g ai/ha
		28 g ai/ha	39 g ai/ha
		34 g ai/ha	45 g ai/ha
Topramezone (Pylex) ²	HPPD Inhibitor (WSSA Group 27)	2.5 g ai/ha	5.0 g ai/ha
		5.0 g ai/ha	8.5 g ai/ha
		7.5 g ai/ha	12 g ai/ha
		10 g ai/ha	15 g ai/ha
		13 g ai/ha	18 g ai/ha
		15 g ai/ha	20 g ai/ha

1) + NIS 0.25% (v/v) 2) + MSO 0.5 % (v/v)

Materials and Methods

- L93 creeping bentgrass maintained at 1.5 cm
- All applications were sprayed at 373 L ha⁻¹ with a hooded sprayer
- Visual observer rated % herbicidal injury focusing on turf color change (Fig 2A, 2B)
- Red and NIR reflectance values were recorded with a spectral sensor which was used to calculate average NDVI for each plot at 7 and 14 DAT (Fig 1A)
- Multispectral images were collected across the field by a drone-mounted multispectral sensor with 90% front and side overlap at 20 m height (Fig 1B)
- An orthomosaic of multispectral images was generated using Pix4Dmapper (Pix4D, Denver, CO) for all plots at each assessment timing (Fig 3A)
- Orthomosaic images were processed using ArcGIS Pro (Esri, Redlands, CA) to calculate average NDVI for each plot (Fig 3B)
- NDVI responses were converted to a percentage reduction compared to non-treated controls
- Linear regression slopes were generated for each replicate in each trial to relate visually observed injury to either ground or drone NDVI, and also for the relationship between ground and drone NDVI

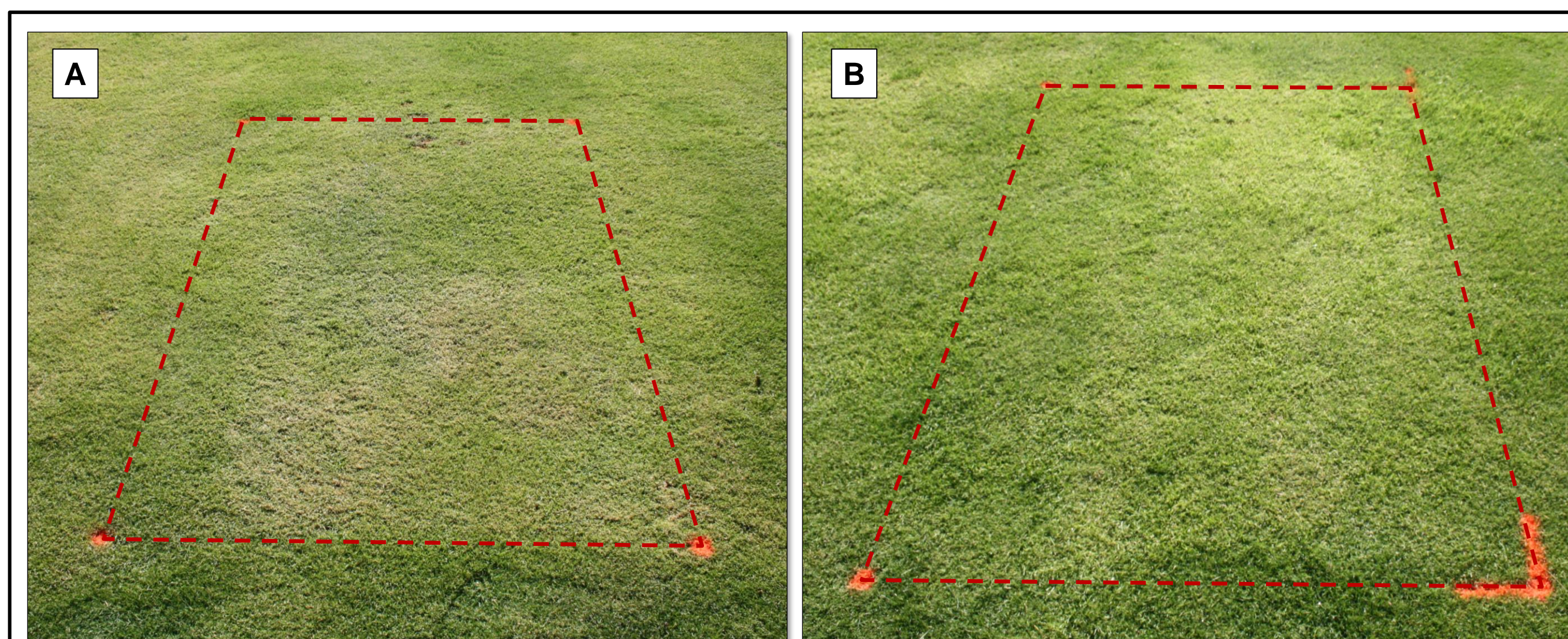


Figure 2. Creeping bentgrass injury due to herbicide application (A) chlorosis and browning symptoms on leaves due to sulfosulfuron (B) bleaching symptoms on newly-emerged leaves due to topramezone

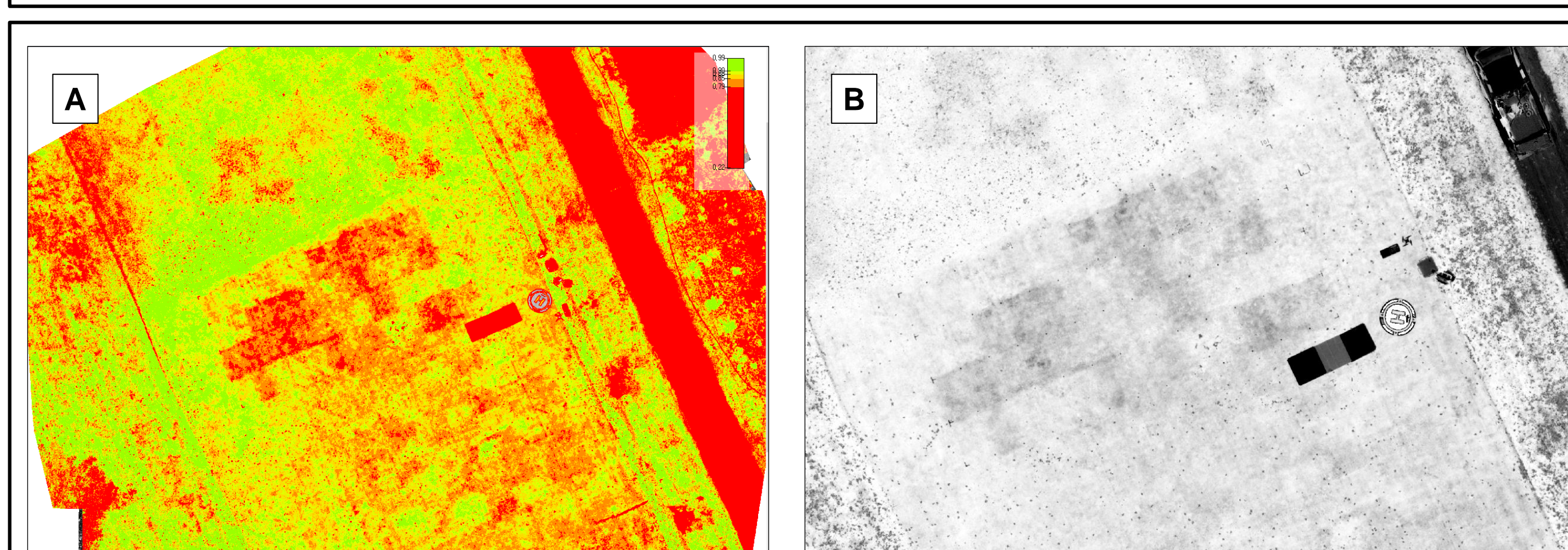


Figure 3. Image processing with multispectral images (A) orthomosaic images generation for red, blue, green, red-edge, and NIR using Pix4Dmapper (B) Composite images from 5 orthomosaic images were created to calculate NDVI for each plot

Results and Discussion

- Although the rates of herbicides used caused a similar range of visual green color loss, NDVI was poorly correlated to visually assessed herbicide injury, is reduced at a much lower rate compared to visual color, and was dependent on herbicide mode of action in one of two years (Fig 4)
- In 2021, the slope of NDVI to visually estimated injury by sulfosulfuron was higher than that of topramezone (slope value of 1 would indicate a perfect relationship) regardless of ground- or drone-based measurement (Fig 4)
- The correlation of drone- and ground-based NDVI resulted in a slope of 0.74 and indicates that ground-based equipment inflates NDVI when compared to drone-based equipment (Fig 5)

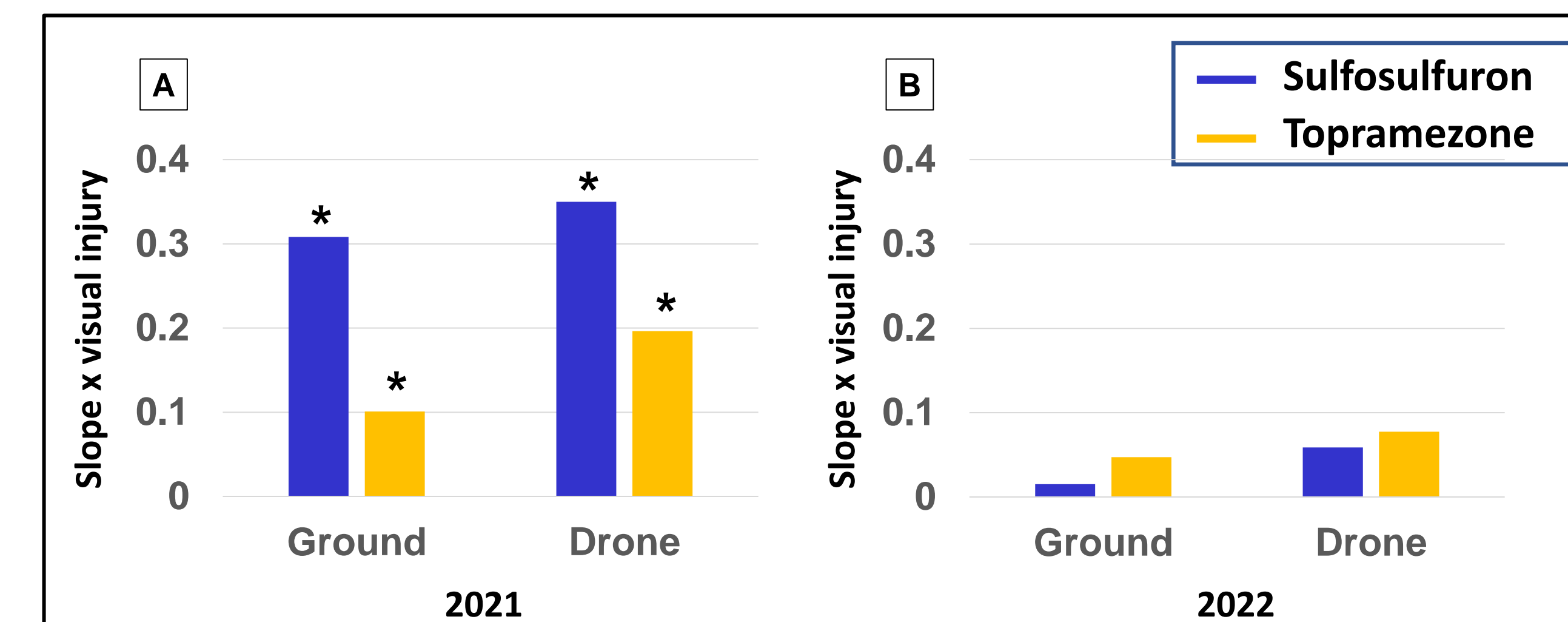


Figure 4. Slope between herbicide visual rating and (A) ground-based NDVI reduction (%) or (B) drone-based NDVI reduction (%) (* denotes difference between herbicides $P \leq 0.05$.)

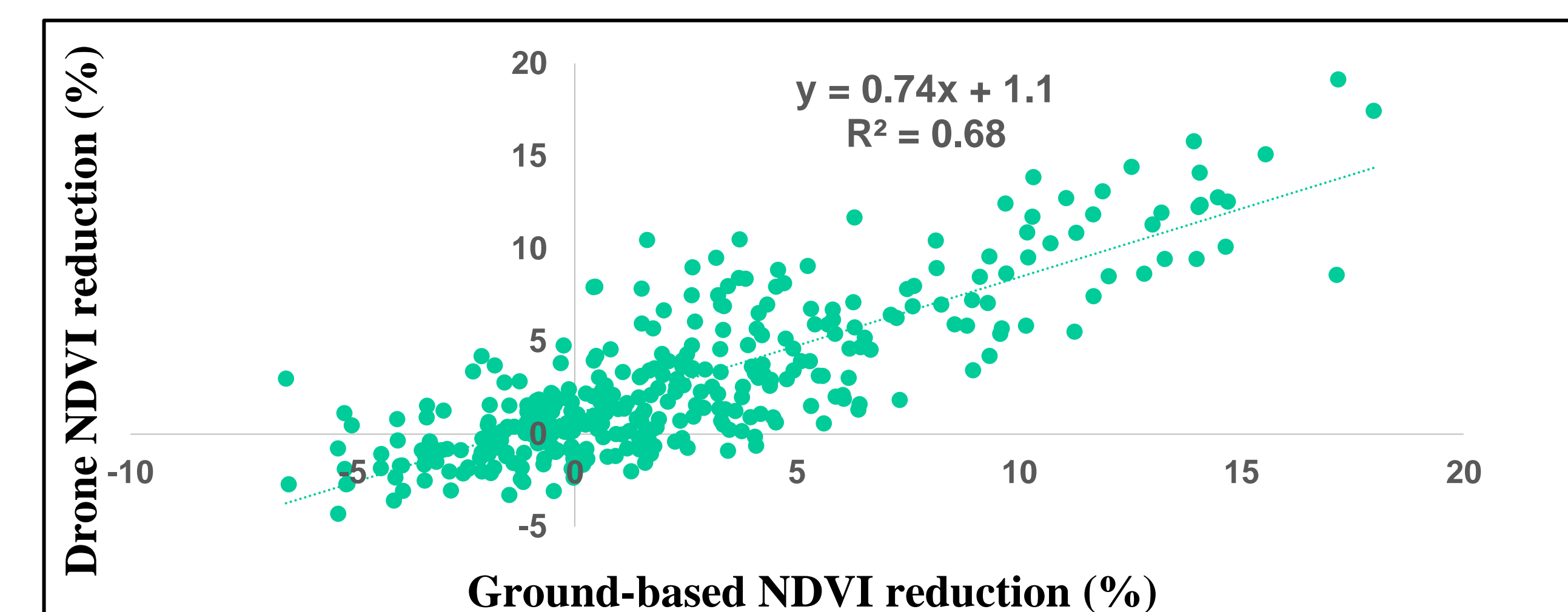


Figure 5. Relationship between NDVI reduction measured by a ground-based device versus a drone-based device

Conclusion

- NDVI is similar between ground and drone assessments, but varies widely between environments and assessment times and should be converted to percentage reductions compared to nontreated turf before assessing herbicide injury
- NDVI could be used to supplement the visual ratings of herbicide injury, however, the relationship might vary depending on herbicide MoA and environment

Reference

Bell, G. E., Martin, D. L., Kuzmic, R. M., Stone, M. L., & Solie, J. B. (2000). Herbicide tolerance of two cold-resistant bermudagrass (*Cynodon spp.*) cultivars determined by visual assessment and vehicle-mounted optical sensing. *Weed technology*, 14(3), 635-641.

Brewer, J. R., Willis, J., Rana, S. S., & Askew, S. D. (2017). Response of six turfgrass species and four weeds to three HPPD-inhibiting herbicides. *Agronomy Journal*, 109(4), 1777-1784.