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Proximal and remote sensing based imaging technology to quantify herbicide responses in field crops

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Abstract

The application of herbicides in agriculture has significantly increased in recent decades. While many herbicides improve the efficiency and efficacy of weed control, their excessive use at the wrong growth stage can cause crop foliar damage, higher input cost and negative environmental footprints. There are limited techniques to accurately monitor herbicide effects. Visual ratings are highly subjective and require extensive training or experience. High-throughput digital imaging is a promising tool to measure plant herbicide interaction in field crops. In this study, proximal and aerial based advanced sensors have been utilized to evaluate different herbicide modes-of-action in two model species, tame oat [*Avena sativa*; model for wild oat (*Avena fatua*)] and oriental mustard [*Brassica juncea*; model for wild mustard (*Sinapis arvensis*)]. The experimental trials were performed at three agro-climatic locations in Canada (Lethbridge (AB), Saskatoon (SK), and Lacombe (AB)). The proximal and UAV multispectral imagery data were collected for baseline (before treatment) and 1, 3, 7, 10, 14 and 21 days after treatments (DAT), alongside visual ratings. The Normalized Difference Vegetation Index (NDVI), Photochemical Reflectance Index, Chlorophyll Vegetation Index, and Optimized Soil Adjusted Vegetation Index were used to assess variation of different DAT pigment content (photosynthetic rate) and chlorosis (damage %) in plot vegetation. The variation in obtained temporal indices (NDVI) suggest that the developed technology has potential to replace visual ratings (R^2 [?]0.65-0.94) and can be used as a rapid screening tool for herbicide activity. Therefore, remote sensing tools could improve the precision and consistency of future herbicide assessments.

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Abstract: The application of herbicides in agriculture has significantly increased in recent decades. While many herbicides improve the efficiency and efficacy of weed control, their excessive use at the wrong growth stage can cause crop foliar damage, higher input cost and negative environmental footprints. There are limited techniques to accurately monitor herbicide effects. Visual ratings are highly subjective and require extensive training or experience. High-throughput digital imaging is a promising tool to measure plant herbicide interaction in field crops. In this study, proximal and aerial based advanced sensors have been utilized to evaluate different herbicide modes-of-action in two model species, tame oat [*Avena sativa*; model for wild oat (*Avena fatua*)] and oriental mustard [*Brassica juncea*; model for wild mustard (*Sinapis arvensis*)]. The experimental trials were performed at three agro-climatic locations in Canada (Lethbridge (AB), Saskatoon (SK), and Lacombe (AB)). The proximal and UAV multispectral imagery data were collected for baseline (before treatment) and 1, 3, 7, 10, 14 and 21 days after treatments (DAT), alongside visual ratings. The Normalized Difference Vegetation Index (NDVI), Photochemical Reflectance Index, Chlorophyll Vegetation Index, and Optimized Soil Adjusted Vegetation Index were used to assess variation of different DAT pigment content (photosynthetic rate) and chlorosis (damage %) in plot vegetation. The variation in obtained temporal indices (NDVI) suggest that the developed technology has potential to replace visual ratings ($R^2 \approx 0.65–0.94$) and can be used as a rapid screening tool for herbicide activity. Therefore, remote sensing tools could improve the precision and consistency of future herbicide assessments.