Using R Based Image Analysis to Quantify Rust on Perennial Ryegrass

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\textbf{Introduction}

- Crown and stem rust caused by \textit{Puccinia coronata} f. sp. lolii and \textit{Puccinia graminis} subsp. graminicola are major diseases of perennial ryegrass (\textit{Lolium perenne} L.) when grown for turfgrass, forage, and seed.
- Plant breeders and pathologists often quantify rust severity in the field using the modified Cobb scale, but this method is subjective, labor intensive, and dependent on the skill and experience of the scorer.
- Our objective was to develop a novel, open-source system that couples both ImageJ and R to quantify rust severity on simple RGB images.
- We validated the system’s performance with count data and visual ratings.

\textbf{Materials and Methods}

\textbf{Plant material and image collection}

Three image series (n = 50 each) were collected from a diverse collection of 50 perennial ryegrass that varied greatly for rust susceptibility.

\textbf{Data collection efficiency}

Five leaf images (FL) were taken in cross pattern from each plant and imaged in the field immediately after placement on an imaging board in a light box lit by 150 cm of high color rendering index LED light strip.

\textbf{Visual scoring of images for rust incidence}

Ability to visually score rust across the three image series was assessed by a panel of high color rendering index LED light strip.

\textbf{Image analysis pipeline}

1. ImageJ was used to generate training data from selected pixels (non-plant, plant, rust).
2. Training data was used to fit random forest models in R.
3. Background pixels were filtered using the random forest model.
4. Rust severity was quantified using R packages random forest and EBImage.

\textbf{Results and Discussion}

\textbf{Assessment of rater variability}

Agreement on severity for SL images was low, as scores approached 50%, the distribution of the rater scores was maximized.

Crown rust scores across all image series all had excellent ICC values, meaning raters had very consistent perceptions of severity. Rater scores for stem rust for showed fair consistency for WP while FL and SL showed good consistency.

\textbf{Correlations between image series}

<table>
<thead>
<tr>
<th>Rater</th>
<th>Computer</th>
<th>WP</th>
<th>FL</th>
<th>SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crown Rust</td>
<td>0.80</td>
<td>0.84</td>
<td>0.86</td>
<td>0.93</td>
</tr>
<tr>
<td>Stem Rust</td>
<td>0.79</td>
<td>0.65</td>
<td>0.93</td>
<td>0.79</td>
</tr>
</tbody>
</table>

\textbf{Consistency and correlation between rater and computer scores}

Computer and rater scores were very consistent for crown rust, but not stem rust. This is likely due to the inability to see stem rust on WP.

Correlations between raters and the computer were excellent for crown rust and SL stem rust images. Stem rust was not significantly correlated for WP.

\textbf{Conclusions}

- An open-source, automated image analysis system was developed and accurately predicted crown rust severity on WP, FL and SL images.
- This system does not accurately quantify stem rust on a whole plant scale, but will work for stem or leaf samples.
- Future research should focus on implementing multispectral imaging that would add additional explanatory power to the random forest model.

\textbf{References}


\textbf{Acknowledgments}

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\textbf{Conflict of Interest}

None declared.