Predicting stripe rust epidemics using regional drought indices and local weather conditions in Kansas

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Introduction

- Stripe rust (*Puccinia striiformis* Westend. f. sp. *tritici* Eriks) caused yield losses of 42.5 million bushels of wheat in Kansas (Figure 1).
- Major epidemics were in 2001, 2003, 2005, and 2010 resulting in 7.3, 10.6, 8.0, and 10.3% statewide yield losses, respectively.
- Stripe rust often overwinters in the southern U.S. and these overwintering sites potentially provide inoculum for epidemics in Kansas.
- With inoculum present, temperature and moisture are the limiting factors for disease development.
- The optimum environmental conditions are 10-18°C with at least 3 hours of moisture. Although the optimum temperature range is narrow, stripe rust can cause infection from 2-23°C.
- The combination of the wide temperature range and minimal moisture requirements indicates that environmental conditions may be conducive for stripe rust infections in many years.

Objective

- The objective of this research is to identify environmental conditions that are conducive to stripe rust epidemics in the central Great Plains region of the U.S., and to develop prediction models for stripe rust epidemics in Kansas.

Methods

- The prediction models were developed based on historical records of stripe rust epidemics occurring in Kansas between 1999 and 2010.
- Observations of disease were combined with monthly summaries of temperature, relative humidity and rainfall from 9 climate regions in Kansas (Figure 2) and Palmer Drought Severity Index (PDSI) from 4 climate regions in southern Texas.
- The association of environmental variables with stripe rust epidemics was evaluated with univariate logistic regression models.
- Variables associated with epidemics were combined to develop candidate prediction models.
- Potential models were evaluated using Firth’s Penalized Logistic Regression (Firth 1993) and validated using cross-validation.

Results

- Evaluation of individual environmental variables indicates that stripe rust epidemics in Kansas are associated with the PDSI for southern Texas. This association was strongest for variables summarizing conditions in February (Table 1).
- Temperature in Kansas during March also appears to be associated with stripe rust epidemics.
- Logistic regression models that combined February PDSI for southern Texas and March temperature for Kansas correctly classified >90% of the stripe rust epidemics and non-epidemics in Kansas (Figure 3).

Table 1. Logistic regression models of stripe rust epidemics in Kansas.

<table>
<thead>
<tr>
<th>Model Variables</th>
<th>AIC&lt;sup&gt;1&lt;/sup&gt;</th>
<th>C&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Accuracy&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Texas PDSI (Feb.)</td>
<td>48.086</td>
<td>0.953</td>
<td>91%</td>
</tr>
<tr>
<td>Average temperature °C (Mar.)</td>
<td>121.49</td>
<td>0.675</td>
<td>67%</td>
</tr>
<tr>
<td>Hours with temperature between 10-18°C (Mar.)</td>
<td>107.671</td>
<td>0.721</td>
<td>71%</td>
</tr>
<tr>
<td>Hours with temperature &gt;12°C (Mar.)</td>
<td>107.25</td>
<td>0.711</td>
<td>71%</td>
</tr>
<tr>
<td>Southern Texas PDSI (Feb.) &amp; hours with temperature between 10-18°C (Mar.)</td>
<td>21.975</td>
<td>0.985</td>
<td>95%</td>
</tr>
<tr>
<td>Southern Texas PDSI (Feb.) &amp; average temperature °C (Mar.)</td>
<td>22.724</td>
<td>0.991</td>
<td>96%</td>
</tr>
<tr>
<td>Southern Texas PDSI (Feb.) &amp; hours with temperature &gt;12°C (Mar.)</td>
<td>34.942</td>
<td>0.979</td>
<td>96%</td>
</tr>
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<sup>1</sup>Akaike Information Criterion.  
<sup>2</sup>Area under the receiver operator characteristic curve.  
<sup>3</sup>Mean percentage of correctly classified cases based on 10-fold cross-validation of 90 cases used to develop and test the logistic regression models.

Conclusions

- Stripe rust epidemics in Kansas are associated with the Palmer Drought Severity Index from southern Texas and temperatures in Kansas during March.
- These results suggest that stripe rust epidemics can be predicted with a high degree of accuracy based on regional drought indices and local weather conditions.
- In the future, these models may help wheat farmers better evaluate the need for fungicide applications and minimize the risk for future yield losses cause by stripe rust in Kansas.

Reference