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Impact and Importance of Foliar Diseases of Alfalfa in Iowa

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Introduction

Alfalfa (*Medicago sativa* L.) occupies the third largest hectarage in Iowa, after corn and soybean. Forage crops are an important component of sustainable farming systems in Iowa. Although management of forage-livestock enterprises is somewhat more complex than the management of row crops, disease management in forage crops has not been researched extensively. Although it is generally accepted that diseases of alfalfa reduce forage yield quality, stand establishment, and life span (Brocious and Kirby, 1988; Wilcoxson et al., 1973), little is known about the impact of foliar diseases on alfalfa production in Iowa.

Alfalfa in Iowa is susceptible to a number of plant pathogens, as evidenced by the prevalence of leaf spots and premature defoliation. However, the pathogens causing these injuries and their relative importance in Iowa have not been determined conclusively. Reliable information concerning the relative importance of alfalfa foliar pathogens and the injury they cause would facilitate prioritization of research needs and the development of cost-efficient disease management programs (Carlson, 1971). Prior to 1991, no comprehensive studies on the seasonality of foliar pathogens and the injury they cause on alfalfa in Iowa had been conducted.

Estimates of loss are a prerequisite to the rational development of any agricultural research program that has plant protection as a component (Mumford and Norton, 1984; Nutter and Gaunt, 1996). Reliable estimates of loss facilitate the objective identification of the relative importance of biotic pests (Nutter et al., 1993). Consequently, limited resources (federal, state, or private farmer) can be assigned on a priority basis to optimize returns from a given effort. Accurate information concerning losses is also needed by growers and plant protection specialists to develop cost-efficient decision thresholds to determine when control measures should be deployed (Brocious and Kirby, 1988; Nutter and Gaunt, 1996, Wilcoxson et al., 1973).

The objectives of this workshop are to (i) to provide information concerning the seasonal occurrence and prevalence of alfalfa diseases in Iowa, (ii) provide information concerning the impact of foliar pathogens on alfalfa yields (crop loss), and (iii) to provide information concerning the relationship between disease intensity in alfalfa yield and monetary returns ($ per acre).
Reference Points for Assessing Alfalfa Yield and Crop Loss

Several reference points for yield must be characterized before plant protection programs can be prioritized according to need (Fig. 1).

The first reference point, **Maximum attainable yield**, is the theoretical yield that could be achieved if the crop was grown under optimum environmental conditions, along with the use of all available crop protection tactics to alleviate the negative impacts of biotic pests. Thus, genetic yield potential—not biotic pests or environment—is the operative factor that limits maximum attainable yield.

**Attainable Yield** is the yield obtained at a specific location when all available crop protection tactics are used to alleviate (as much as possible) the stresses caused by biotic pests. Thus, attainable yield is site-specific and is the yield obtained when biotic pests are alleviated but environmental (abiotic) factors such as soil fertility, water availability, growing degree days, etc., may still be limiting yield. Attainable yields are commonly achieved in well-managed experimental plots.

The cost of deploying all available pest management tactics to achieve attainable yield may be higher than the return expected from the sale of the crop and/or may harm the environment because of excessive inputs. In contrast, **economic yield** is the achievable yield that provides the highest net return on expenditure. If the cost of utilizing a new disease management technology exceeds the expected return, the technology is not likely to be adopted.

**Actual yield** is the production level achieved when producers utilize the best disease management programs currently available for a crop, yet several biotic factors (weeds, diseases, insects) are still limiting yield. The difference between actual and attainable yield is the method used by the Food and Agriculture Organization (FAO) to report crop losses (Chiarappa, 1981). Most, if not all, pest management practices are aimed at closing the gap between actual and attainable yield.
**Primitive yield** is the yield achieved when no disease or pest control tactics are utilized. The difference between primitive yield and actual yield represents the improvement presently achieved by the development and use of accepted integrated pest management practices.

**Terms and Concepts for Alfalfa Crop Loss**

**Crop injury** is defined as the visible or measurable symptoms and/or signs caused by plant pathogens or pests, and **crop damage** is defined as any reduction in the quantity and/or quality of yield that results from crop injury (Nutter et al., 1993). Plant pathology evolved into its own science not because plant pathogens cause injury, but because injury often results in loss of revenue or direct loss of a food source (damage) (Nutter et al., 1993). Injury (disease intensity) can often be measured quantitatively. For example, disease incidence has the dimensions \( n/N \), since incidence is defined as the number of diseased sampling units (\( n \): leaves, stems, plants) divided by the total number of sampling units assessed (\( N \)) (Nutter et al., 1991). Disease severity may have the dimensions \( n/L^2 \) (number of lesions per unit leaf area), or \( n/N \) where \( n \) is (number of lesions and \( N \) is the number of sampling units assessed), or \( L^2/L^2 \) (visible diseased leaf area/total leaf area).

Due to unknown pesticide residue tolerances for dairy animal feeds, effective fungicides are not registered for use on alfalfa. Although fungicides are not used as a method to control alfalfa diseases, we used fungicides to measure the potential forage yields that could be achieved in Iowa if foliar diseases were better managed. The yield gaps (potential yield with fungicides minus actual grower yield without using fungicides) were substantial and consistent over a number of locations and years in Iowa (Table 1).

**Table 1. Documented Yield Gaps in Alfalfa Caused by Alfalfa diseases in Iowa.**

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>First Cutting</th>
<th>Second Cutting</th>
<th>Third Cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankeny</td>
<td>1991</td>
<td>35</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>Chariton</td>
<td>1991</td>
<td>20</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Ames</td>
<td>1992</td>
<td>9</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Chariton</td>
<td>1992</td>
<td>21</td>
<td>29</td>
<td>27</td>
</tr>
<tr>
<td>Ames</td>
<td>1995</td>
<td>27</td>
<td>34</td>
<td>--a</td>
</tr>
<tr>
<td>Nashua</td>
<td>1995</td>
<td>16</td>
<td>33</td>
<td>28</td>
</tr>
<tr>
<td>Ames</td>
<td>1996</td>
<td>19</td>
<td>9</td>
<td>13</td>
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<tr>
<td>Ames</td>
<td>1997</td>
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<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Nashua</td>
<td>1997</td>
<td>8</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Ames</td>
<td>1998</td>
<td>12</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>Nashua</td>
<td>1998</td>
<td>10</td>
<td>17</td>
<td>14</td>
</tr>
</tbody>
</table>

*There were only two harvests in the seeding year.*

Thus, our previous research (funded in part by the Leopold Center for Sustainable Agriculture and the National Pesticide Impact Assessment Program) has provided undeniable evidence that there is a tremendous opportunity to increase the sustainability of forage production systems if cost-effective and environmentally-friendly management alternatives can...
be developed. Therefore, future research needs to address mitigation technologies to improve
disease management in alfalfa forage production systems. Biological control of plant pathogens
and inducers of systemic acquired resistance have been a primary focus of many studies in plant
protection that have the goal of developing alternatives to the use of agrichemicals to maximize
genetic yield potentials. Thus, biologically-intensive farming practices could the key to closing
the yield gap caused by foliar diseases of alfalfa in Iowa.

Applying these reference points to the alfalfa pathosystem in Iowa, what are the disease
organisms that are having the greatest negative impact on alfalfa yields in Iowa? Based on our
research, there is a complex of five fungal pathogens that are largely responsible for actual yields
falling below attainable yields (yield gap) (Figure 2).

Alfalfa Crop Loss Factors in Iowa

<table>
<thead>
<tr>
<th>Yield Gap (Crop loss)</th>
<th>Attainable Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor A: <em>Phoma medicaginis</em></td>
<td></td>
</tr>
<tr>
<td>Factor B: <em>Leptosphaerulina trifoli</em></td>
<td></td>
</tr>
<tr>
<td>Factor C: <em>Pseudopeziza medicaginis</em></td>
<td></td>
</tr>
<tr>
<td>Factor D: <em>Cercospora medicaginis</em></td>
<td></td>
</tr>
<tr>
<td>Factor E: <em>Stagonospora meliloti</em></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Disease factors in Iowa preventing alfalfa growers from
reaching attainable yields

Factor A, the most important, is the disease known as spring black stem and leaf spot, caused by
*Phoma medicaginis*. This disease occurs most often between early spring and early summer
(Figure 3). There is a summer complex of diseases that affect the second and third cuttings in
Iowa. These are Leptosphaerulina leaf spot, Pseudopeziza leaf spot (common leaf spot) and
cercopora summer leaf spot (Figure 3). *Stagonospora meliloti* causes mostly a late summer
disease (leaf spot) that contributes to yield reductions in the third cutting. These fungi cause leaf
spots, which leads to leaf loss (defoliation) prior to cutting (Figure 4). Because the environment
(temperature, rainfall, and duration of leaf wetness) plays an important role in the severity of
foliar diseases will have more impact on defoliation in some growth cycles (cuttings) than others.
For example, Figure 4 shows that percentage defoliation reached 30% and 40% in the first and
second cuttings in Knoxville, Iowa, however, less than 8% defoliation occurred during the
second growth cycle because the environment was unfavorable for fungal diseases to develop.
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Figure 4: Effect of foliar pathogens on percentage defoliation in Knoxville, IA (3-cut system)
Figure 3: Seasonality of alfalfa foliar pathogens in Ankeny, IA in 1991
Relationships Between Disease Intensity, Crop Loss, and $ Returns

A chain of quantitative information is needed along with appropriate linkages: injury—damage—monetary loss—economic damage threshold. These linkages are needed because injury data, by itself, is insufficient to develop thresholds. Injury is not the same thing as damage. Injury (X) assessed at one point in time (Nutter and Gaunt, 1996) must be interpreted to project damage at some future point in time (usually plant maturity or harvest). This linkage (equation) is known as the damage function. The partial regression coefficient (slope of the equation) that relates injury to damage is known as the damage coefficient. For example, Figure 5 shows that defoliation assessed just prior to cutting has good relationship with alfalfa yield.

![Graph showing the relationship between percentage defoliation and yield loss (tons/acre) in alfalfa for the second cutting in Nashua, Iowa in 1998. The equation is Y = 0.0197X and R^2 = 0.51.]

The damage coefficient (slope = 0.0197) indicates that for each 1% increase in defoliation, alfalfa yield was decreased by approximately 0.2 tons/acre. There may be more than one damage coefficient if injury affects quality as well as quantity of yield. These relationships can be expressed in terms of how both increases in percentage defoliation and decreases in forage quality (as affected by diseases) impact on yield in monetary terms ($ per acre) (Figure 6).
Figure 6: Effect of percentage defoliation and quality on gross return ($ per acre/cutting).

Mitigation Strategies

1. Disease resistance to multiple pathogens
2. Time of cutting (disease thresholds?)
3. Biological control (need research)
4. Fungicides (not currently registered)

Reference


