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A Degree Day Model of Sheep Grazing Influence on Alfalfa Weevil and Crop Characteristics

Hayes Goosey, Pat Hatfield, Rodney Kott, and Dennis Cash

Montana State University, Bozeman
Bozeman, MT 59717

Background
Alfalfa, *Medicago sativa* (L.), is produced on approximately 1.8 million acres in Montana and is the foremost forage crop in many high, semiarid, intermountain states. Two biological stressors (insects and weeds) combined with poor field management are primarily responsible for reduced alfalfa production. In the U.S. alone, arthropods cause an estimated $260 million loss to alfalfa with the alfalfa weevil, *Hypera postica* Gyllenhal, being the most damaging. In colder northern states, such as Montana, temperatures restrict the weevil’s winter activity. Invertebrate animals such as alfalfa weevil require a certain amount of heat to develop from one point in their life cycles to another. Degree days units are the accumulated product of time and temperature and can be used to estimate the developmental rate of these organisms.

Purpose Statement
Sheep grazing is emerging as a legitimate integrated pest management tactic. Previous work at MSU found that targeted sheep grazing, reduced alfalfa weevil larvae below the economic threshold without impacting alfalfa quality or quantity. A degree day predictive model, that assists producers to make grazing decisions based on degree day accumulations, would improve the effectiveness of alfalfa weevil control and encourage acceptance of this strategic grazing practice. The objective of this research was to establish a predictive model which will identify sheep stocking rates and associated degree day accumulations which will keep alfalfa weevil larvae below the economic threshold and not reduce alfalfa relative growth rates.

Summary of Findings
There was one non-grazed (NG) treatment, established prior to grazing, and 6 grazed treatments (G1, G2, G3, G4, G5, G6) each study year. As grazing treatment number increases from one to six, so does the stocking rate and degree day accumulation associated with the grazing event.

Degree day accumulations during the alfalfa weevil sampling period were regressed against weevil larvae numbers collected from the modeled grazing treatments. Generally, as stocking rate and degree day accumulations increased larvae decreased in grazed plots, which suggests that as grazing is allowed to proceed to increasing degree days, in the spring, the larger the impact on subsequent weevil larvae populations. The relationship is presented in Fig. 1.

Grazing reduced treatment yield and increased forage quality but did not alter plant growth rates. Subsequently, a second model was built to predict at what degree day the yield of the modeled treatments would equal that of the averaged yield of the less extensively grazed treatments (Fig. 2).

Conclusions
In general, as stocking rate and degree day accumulation of the grazing event increased, alfalfa weevil larvae and relative plant aged decreased, however, the growth rate of the alfalfa was not altered.

Results indicated that in general, grazing decreased NDF, ADF, TDN, and Yield and increased CP (Table 1) which leads to the conclusion that alfalfa located in grazed treatments was more digestible and nutritious but yielded less. The physical act of grazing keeps plants, including alfalfa, at a younger growth stage by retarding development, through removal of biomass, and minimizing maturation. Younger plants are relatively more digestible and nutritious but are generally smaller when compared to relatively older plants. Differences in yield and alfalfa forage qualities associated with individual grazing treatments was a function of relative plant age which was determined by stocking rate and degree day accumulation. In general, as stocking rate
and degree day of the grazing event increased, relative plant age decreased. This is supported by grazing treatment plant growth stage (MSW) which is indicator of plant maturity (Table 1).

Applications
These data indicate that the grazing intensity necessary to manage alfalfa weevil populations does not affect the plants growth rate rather it delays harvest. To manage alfalfa weevil, the recommendation from this research is to stock alfalfa fields in the spring prior to 34 cumulative degree days with rates between 102 and 236 sheep days/acre. Sheep should be allowed to graze to a minimum of 106 and maximum of 150 degree days before removal. The minimum number ensures that grazing has proceeded far enough into the spring to manage the weevil and the maximum is the point where grazing must be stopped to ensure that the model predicting equal stem biomass and yields is accurate. At the central MT site where this research was conducted this historically falls between the 6th and 18th of May. Since the weevil hibernates in northern latitudes we only expect this model to only work in the same places.

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Figure 1. Modeled treatment AW larvae numbers during the crop growth period as a function of DD.

\[ \text{Larvae} = -1.316963 + 0.00751 \text{DD} \]

\[ N = 24; R^2 = 0.8271; \text{RMSE} = 0.1963; P < 0.0001 \]

Figure 2. Stem biomass (ln) of modeled treatments as a function of DD.

\[ \text{lnbiomass} = -1.034 + 0.0067 \text{DD} \]

\[ N = 40; R^2 = 0.7452; \text{RMSE} = 0.5826; P < 0.0001 \]

Table 1. Grazing treatment alfalfa MSW, NDF, ADF, CP, TDN and Yield during 2008 and 2009.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>MSW*</th>
<th>NDF(%)</th>
<th>ADF(%)</th>
<th>CP(%)</th>
<th>TDN</th>
<th>Yield</th>
<th>S.E.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NG</td>
<td>5.1a</td>
<td>43.13ab</td>
<td>30.22a</td>
<td>20.78a</td>
<td>65.02a</td>
<td>4.61a</td>
<td>0.10</td>
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<td>G1</td>
<td>4.9b</td>
<td>43.08ab</td>
<td>30.55a</td>
<td>19.07a</td>
<td>64.76a</td>
<td>4.15a</td>
<td>2.86</td>
</tr>
<tr>
<td>G2</td>
<td>4.2c</td>
<td>42.84ab</td>
<td>30.95a</td>
<td>19.77a</td>
<td>64.45a</td>
<td>3.96ab</td>
<td>1.66</td>
</tr>
<tr>
<td>G3</td>
<td>4.0d</td>
<td>43.41ab</td>
<td>30.28a</td>
<td>20.86a</td>
<td>64.98a</td>
<td>3.30bc</td>
<td>0.88</td>
</tr>
<tr>
<td>G4</td>
<td>4.0d</td>
<td>45.66a</td>
<td>27.76ab</td>
<td>21.52ab</td>
<td>66.97a</td>
<td>2.21c</td>
<td>0.88</td>
</tr>
<tr>
<td>G5</td>
<td>3.9d</td>
<td>39.07bc</td>
<td>27.74ab</td>
<td>22.67bc</td>
<td>66.99a</td>
<td>2.76c</td>
<td>0.88</td>
</tr>
<tr>
<td>G6</td>
<td>2.2e</td>
<td>34.49c</td>
<td>24.71b</td>
<td>23.66c</td>
<td>69.38b</td>
<td>1.51d</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Means in columns followed by the same letter grouping are not significantly different (\(P>0.05\)); least squared means/least significant difference analysis (Proc Mixed; SAS Institute 2002).

*Mean Stage by Weight: Higher values indicate more mature plants.

TDN (% of DM) = 82.38-(0.7515 x ADF%).

Yield: Metric Tons/Hectare.

Standard error of the least squared means/least significant difference analysis.