Forage Plant Response to Defoliation

Importance of Defoliation Management

Forage Quality

Forage Yield

Stand Life

An important goal in most forage programs is to maximize economic yield of nutrients while insuring stand persistence.

Elements of Defoliation

- Timing of first harvest in a season
- Frequency of harvest (time interval)
- Timing of the last harvest
- Number of harvests per year
- Defoliation height
  - Sward height or mass
  - Stubble or cutting height or residue

Defoliation Intensity

- Low
  - Exp. - one hay cut/year
  - Mass and sward height
  - Residue and cutting height

- Medium
  - Exp. - 3 hay cuts/year

- High
  - Exp. - Rotational grazing

- Very High
  - Exp. - continuous grazing

Defoliation Intensity

What is the affect of defoliation intensity on:

- Growth Rate and Yield
- Seasonal distribution
- Forage Quality
- Stand persistence

Plant Response to Defoliation

The plant response to defoliation depends on many variables:

- The physiological, morphological and anatomical characteristics of each forage
- The botanical composition of the forage stand (if a mixed stand)
- The environmental conditions in which forage plants are growing

What is the plant response to defoliation intensity?
Forage Plant Response to Defoliation

### Physiological Characteristics - Stored Energy

Plants require energy for growth and maintenance. Photosynthesis (PSN) is the primary source of plant energy in the form of carbohydrates. Food reserves are usually stored in roots or basal portions of perennial forages and are an important source of energy for 1) overwintering, 2) initial spring growth, and 3) regrowth after defoliation.

### Morphological Characteristics

#### Plant Shape and Height

<table>
<thead>
<tr>
<th>Cutting Or Grazing Height</th>
<th>Erect (tall)</th>
<th>Prostrate (short)</th>
</tr>
</thead>
</table>

Upright or tall growing species must rely almost entirely on stored energy for new growth whereas short or prostrate species can utilize photosynthesis of low growing leaves for energy.

### Food Reserves

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### Stored Energy

- **Food reserves** are usually stored in roots or basal portions of perennial forages and are an important source of energy for 1) overwintering, 2) initial spring growth, and 3) regrowth after defoliation.

### Physiological Characteristics

Plants would prefer to grow new leaves by producing carbohydrates with old leaves than by moving stored carbohydrates. It’s easier and more efficient.

### Tall Species

- **Alfalfa**
- **Red clover**
- **Upright varieties of birdsfoot trefoil**
- **Alsike clover**
- **Timothy**
- **Smooth bromegrass**
- **Orchardgrass**
- **Tall fescue**
- **Reed canarygrass**

### Short Species

- **'Empire' type varieties of birdsfoot trefoil**
- **Common and Dutch varieties of white clover**
- **Tetraploid Per. Ryegrass**
- **Meadow fescue**

### Intermediate Species

- **Intermediate varieties of birdsfoot trefoil**
- **Ladino type of white clover**
- **Tetraploid Per. Ryegrass**
- **Meadow fescue**

### Tall Species

- **Alfalfa**
- **Red clover**
- **Upright varieties of birdsfoot trefoil**
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### Short Species

- **'Empire' type varieties of birdsfoot trefoil**
- **Common and Dutch varieties of white clover**
- **Kentucky bluegrass**
- **Some diploid per. ryegrasses**
Cultivars can also vary in their morphology and response to defoliation. Newer, lower growing orchardgrass varieties will persist better under more frequent and shorter residual height grazing.
Forage Plant Response to Defoliation

**Anatomical Characteristics**

- **Jointing grasses:** (GP elevates at regrowth)
  - Timothy
  - Smooth bromegrass
  - Reed canarygrass
- **Non-jointing grasses** (GP stays at crown)
  - Orchardgrass
  - Tall and meadow fescue
  - Perennial ryegrass
  - Ky. bluegrass

**Grass Types**

**Plant Response to Defoliation Intensity**

- Non-jointed, bunch grasses (like orchardgrass, tall fescue, perennial ryegrass) can recover from defoliation quite rapidly since the growing point is below the cutting height and developing leaves never stop growing.
- Legumes and jointed grasses are slower to recover since new growth must be initiated from either crown buds or axillary buds on stems close to the ground and rely on stored energy for initial growth.

**Location of Growing Points**

- **Apical Dominance**
  - Many species have strong apical dominance (alfalfa, red clover, timothy and smooth bromegrass) which means axil and crown bud development is inhibited until the apical meristem is removed.
  - Other species such as orchardgrass express very little apical dominance (they continue to tiller and produce basil leaves even as the reproductive stem elongates).

**Physiological Characteristics - Stored Energy**

- **Example: Alfalfa**
  - High Dry Matter Yield
    - Insufficient PSN, rely on stored energy
    - Sufficient PSN for growth
      - Excess PSN, energy reserves are replenished
  - Low Stored Energy Reserves
    - Time (days from initiation of growth)
      - Low

**Morphological Characteristics**

- **Plant Shape and Height**
  - Erect (tall)
  - Prostrate (short)
  - Upright or tall growing species or species with strong apical dominance must rely almost entirely on stored energy for that initial new growth.
Forage Plant Response to Defoliation

Physiological Characteristics - Stored Energy

- **Example:** Alfalfa
- **Dry Matter Yield:** High or Low
- **Stored Energy Reserves:** High or Low
- Time (days from initiation of growth)

- Early cut
- Regrowth

Frequent early cutting depletes energy reserves causing reduction in stand persistence.

**Forage Cutting Height**

- Lower cutting results in more yield from that harvest
  - 0.5 t/a per year for each inch of alfalfa
- Lower cutting height reduces forage quality
  - 5 points Relative Feed Value per inch cutting height
- Lower cutting height shortens stand life of grasses
  - Especially smooth bromegrass, orchardgrass, timothy
- Lower cutting height increases ash with disc mowers
- Best compromise is generally 3 to 4 inches cutting height

USDA-Dairy/Forage Research Lab 2010

**What is the impact of overgrazing?**

Source: Geoff Brink, USDA-ARS

An adequate residual height, which promotes quicker regrowth, also shortens the length of time before cattle can graze in the same pasture again.

**Residual height affects rotation time**

Source: Geoff Brink, USDA-ARS

This graph shows the rate at which grass grows depending on the residual height. The rate increases as residual increases - until the grass is long enough to start shading the underside of the plant and slowing down the growth.

**Residual height affects pasture growth rate**

Source: Geoff Brink, USDA-ARS

**Plant Response to Defoliation Intensity**

Impact on Forage Quality

Source: Geoff Brink, USDA-ARS
Grasses and Forage Quality
Two locations (E. Montpelier, S. Burlington)
Two years (2002, 2003)
Three grasses:
  • Orchardgrass (three cultivars)
  • Timothy (two cultivars)
  • Reed canarygrass (one cultivar)
Alfalfa (pure and in mixture with each grass)

Samples were taken from early May to mid-June

Dates when first 5% of tillers in each stand reached boot/early head stage
(East Montpelier, VT)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pizza OG</td>
<td>6/3</td>
<td>6/4</td>
</tr>
<tr>
<td>Barindana OG</td>
<td>6/3</td>
<td>6/4</td>
</tr>
<tr>
<td>Pennlate OG</td>
<td>5/29</td>
<td>5/29</td>
</tr>
<tr>
<td>Sunrise Tim</td>
<td>6/10</td>
<td>6/12</td>
</tr>
<tr>
<td>Sunset Tim</td>
<td>6/14</td>
<td>6/18</td>
</tr>
<tr>
<td>Palaton RCG</td>
<td>6/10</td>
<td>6/12</td>
</tr>
</tbody>
</table>

Optimum NDF for grasses
Grasses increased about 0.75% NDF per day
Alfalfa increased about 0.52% NDF per day

Optimum NDF for alfalfa
Alfalfa increased about 0.52% NDF per day

Colored arrows indicate date of boot/early head
Too late at these stages
Boot stage and high quality - A good time to cut for orchardgrass but too late for timothy or reed canarygrass. Why?
Forage Plant Response to Defoliation

Staging Grasses

Vegetative  Elongating  Boot  Heading

Tiller Stages of Grass Treatments

Yield Pizza Orchardgrass  East Montpelier  2003

Yield Pennlate Orchardgrass  East Montpelier  2003

Yield Sunrise Timothygrass  East Montpelier  2003

Yield Sunset Timothygrass  East Montpelier  2003

How does this affect forage quality of these grasses?

Tiller Stages of Grass Treatments

Can we cut the Timothy earlier to achieve higher quality?

Plant Response to Defoliation Intensity

- Intolerant of early first cut:
  - Smooth bromegrass
- Less tolerant of early first cut:
  - Timothy (variety dependent)
- Tolerant of early first harvest:
  - Orchardgrass
  - Reed canarygrass
  - Tall fescue/meadow fescue
  - Perennial ryegrass

Montserrat 1995

Environmental Interaction

Spring Growth  Summer Growth

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Forage Plant Response to Defoliation

**Grass Quality**

![Graph showing the relationship between time and neutral detergent fiber digestibility and crude protein content of grasses.](Brink, USDA-Dairy/Forage Research Lab, 2010)

**Environmental Interaction**

- **Spring Growth**
- **Summer Regrowth**

**Flowering Culm**

Most cool season grasses have a winter requirement for floral induction that may include both short days and low temperatures (vernalization) although some only require one or the other. Timothy requires no winter induction only long days. The spring initiation phase is also referred to as secondary induction.

**Relative Heading Date**

<table>
<thead>
<tr>
<th>Species</th>
<th>Early</th>
<th>Medium</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchardgrass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early varieties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late varieties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perennial Ryegrass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early varieties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late varieties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth bromegrass</td>
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<td></td>
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<tr>
<td>Tall fescue</td>
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</tr>
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<tr>
<td>Late varieties</td>
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</tbody>
</table>

**Date of Grass Seedhead Development**

UVM Farm

50 Timothy cultivars
30 Orchardgrass cultivars
Seeded in fall 1995
Evaluated in 1997 and 1998

“Heading Date” was determined when the first five fillers in each plot reached early head emergence.

**Time of Grass Seedhead Development As Influenced By Temperature and Day Length**

![Graph showing frequency distributions for date of heading for the same set of orchardgrass varieties (n=30) and timothy varieties (n=44) in 1997 and 1998, respectively.](http://pss.uvm.edu/vtcrops/?Page=research/GrassVarieties.html)
Forage Plant Response to Defoliation

**Temperature and Grass Quality**

Orchardgrass did appear to respond to temperature more than timothy.

**Plant Response to Defoliation Intensity**

**Environmental Interaction**

**Defoliation and Drought**

- During deficit water stress, plants rely more on stored carbohydrates for growth.
- During deficit water stress, growth slows down due to a lack of turgor pressure; however, photosynthesis continues at least until stomates close due to more severe drought.
- Therefore, leaf area is extremely important for new growth and residual height and longer rest periods are critical to assure adequate storage of CHO.

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**Defoliation and Fall Management of Grasses**

- In late summer, cool season grasses produce new tillers that will be the basis for growth the following spring.
- Severe defoliation at this time can greatly reduce potential production the next season.
- It is best to let grasses grow uninterrupted 3 or 4 leaves before a killing frost to store sufficient CHO's.
- If grazed after this, leave a 3 to 4 inch residue.

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**Defoliation and Fall Management of Alfalfa**

- Mismanagement in the fall can lead toward winter injury of alfalfa.
- One option is to leave the stand uncut going into the winter.
- If making a fall harvest, consider the previous cutting management. When cutting intervals are 35 days or less, it is best to avoid harvesting between early September and mid-October; otherwise, make sure there is 45 days between the late summer and fall harvest.
- Make sure soil K levels are adequate to high.
- Leave a 4 to 6 inch stubble.

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**Botanical Composition**

In a mixed stand of orchardgrass and alfalfa.

- A higher cutting or grazing height usually favors the grass.
- Grass shoots continue to grow after defoliation so their regrowth is rapid.
- Legumes must initiate new growth from crown or lower axillary buds so regrowth is slower.

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Forage Plant Response to Defoliation

Botanical Composition

In a mixed stand of grass and legume

- A lower cutting or grazing height tends to favor the legume.
- In grasses, a low defoliation height removes more leaf area and part of the stored energy reserves (found in the basal portions of the grass stems); therefore, their regrowth is slowed down.

<table>
<thead>
<tr>
<th>Grass Species</th>
<th>Growth Type</th>
<th>Time of Heading</th>
<th>Apical Dominance</th>
<th>Tolerance to Early First Cut</th>
<th>Vegetative Growth</th>
<th>Cutting Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy</td>
<td>Bunch</td>
<td>Medium-late to Late</td>
<td>Strong</td>
<td>Intolerant</td>
<td>Jointing</td>
<td>40 - 45</td>
</tr>
<tr>
<td>Smooth bromegrass</td>
<td>Sed</td>
<td>Medium-late</td>
<td>Strong</td>
<td>Intolerant</td>
<td>Jointing</td>
<td>40 - 45</td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td>Sed</td>
<td>Medium</td>
<td>Moderate</td>
<td>Somewhat Tolerant</td>
<td>Jointing</td>
<td>35 - 40</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>Bunch</td>
<td>Early to Medium</td>
<td>Weak</td>
<td>Tolerant</td>
<td>Non-jointing</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>Bunch 1</td>
<td>Medium</td>
<td>Somewhat Weak</td>
<td>Tolerant</td>
<td>Non-jointing</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Meadow fescue</td>
<td>Bunch</td>
<td>Medium</td>
<td>Somewhat Weak</td>
<td>Tolerant</td>
<td>Non-jointing</td>
<td>35</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>Bunch</td>
<td>Early to Medium</td>
<td>Weak</td>
<td>Tolerant</td>
<td>Non-jointing</td>
<td>30 - 35</td>
</tr>
</tbody>
</table>

1 Some cultivars and ecotypes have been found to produce short rhizomes
2 Wide range in calibrating heading dates for timothy, orchardgrass and perennial ryegrass

Resources

http://palspublishing.cals.cornell.edu/nra_order.taf

Our PDP website: http://pss.uvm.edu/pdpforage/