



# Developmental stages of timothy and alfalfa

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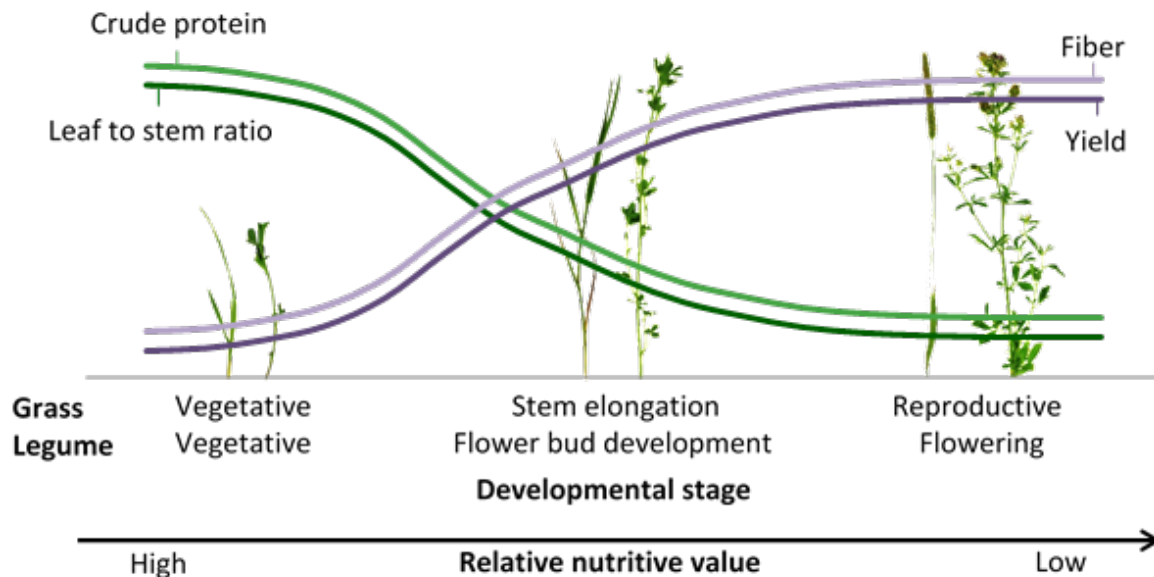
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# Foreword

The developmental stage at which forage crops are harvested greatly affects their yield, nutritive value, and persistence. Throughout their growth, plants use energy from the sun, carbon dioxide from the air and water to synthesize carbohydrates via photosynthesis. The carbohydrates produced allow plants to grow, increasing their yield. Throughout the last weeks of each growth cycle as well as during the fall, perennial forage plants store nutrients, which allow them to regrow after each cut and in the spring. Harvesting forage plants at a more advanced developmental stage thus promotes the yield and persistence of perennial forage crops. Moreover, the developmental stage at harvest is a key factor in determining the nutritive value of the resulting forage. As a plant becomes older, the fiber content increases, the cell walls lignify, and the leaf to stem ratio decreases. These changes reduce the crude protein concentration as well as the digestibility of the dry matter and fibers of the forage, which becomes less palatable, less consumed and less efficiently used by ruminants.

It is therefore important to accurately evaluate the developmental stage of forage crops in order to precisely establish the appropriate harvest time and to optimize their yield, nutritive value and persistence. This guide illustrates and explains the developmental stages of timothy and alfalfa, the two main forage species cultivated in Quebec. It also describes two methods used to determine the mean stage of such forage: the Mean Stage by Count (MSC) and the Mean Stage by Weight (MSW).

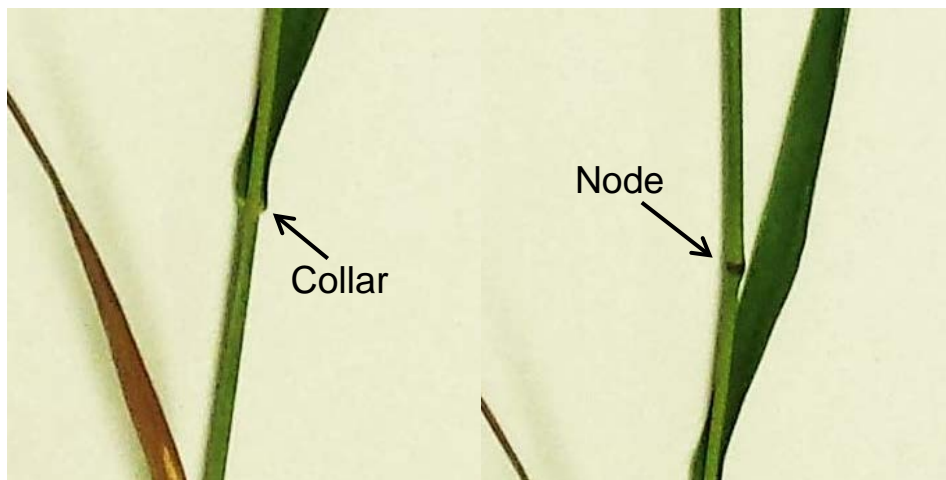
## Effects of the developmental stage of plants on their yield and nutritive value.



Adapted from Blaser, R., R.C. Hammes, Jr., J.P. Fontenot, H.T. Bryant, C.E. Polan, D.D. Wolf, F.S. McLaugherty, R.G. Klein, and J.S. Moore. 1986. Forage-animal management systems. Virginia Polytechnic Institute, Bulletin 86-7.

# Timothy developmental stages

|   | Stage   |       | Characteristics                 |
|---|---------|-------|---------------------------------|
|   | Name    | Index |                                 |
| <b>Vegetative<br/>(foliar<br/>development)</b>          | V0 (VE) | 1.0   | Emergence of the first leaf     |
|   | V1      | 1.1   | First leaf with collar          |
|   | V2      | 1.3   | Second leaf with collar         |
|   | V3      | 1.5   | Third leaf with collar          |
|   | V4      | 1.7   | Fourth leaf with collar         |
|   | V5      | 1.9   | Fifth leaf with collar          |
| <b>Stem elongation</b>                                  | E0      | 2.0   | Elongation between collars      |
|   | E1      | 2.1   | First palpable/visible node     |
|   | E2      | 2.3   | Second palpable/visible node    |
|   | E3      | 2.5   | Third palpable/visible node     |
|   | E4      | 2.7   | Fourth palpable/visible node    |
|   | E5      | 2.9   | Fifth palpable/visible node     |
| <b>Reproductive<br/>(inflorescence<br/>development)</b> | R0      | 3.0   | Swelling at the apex            |
|   | R1      | 3.1   | Inflorescence partially visible |
|   | R2      | 3.3   | Inflorescence entirely emerged  |
|   | R3      | 3.5   | Peduncle entirely emerged       |
|   | R4      | 3.7   | Emergence of anthers            |
|   | R5      | 3.9   | Fertilization                   |

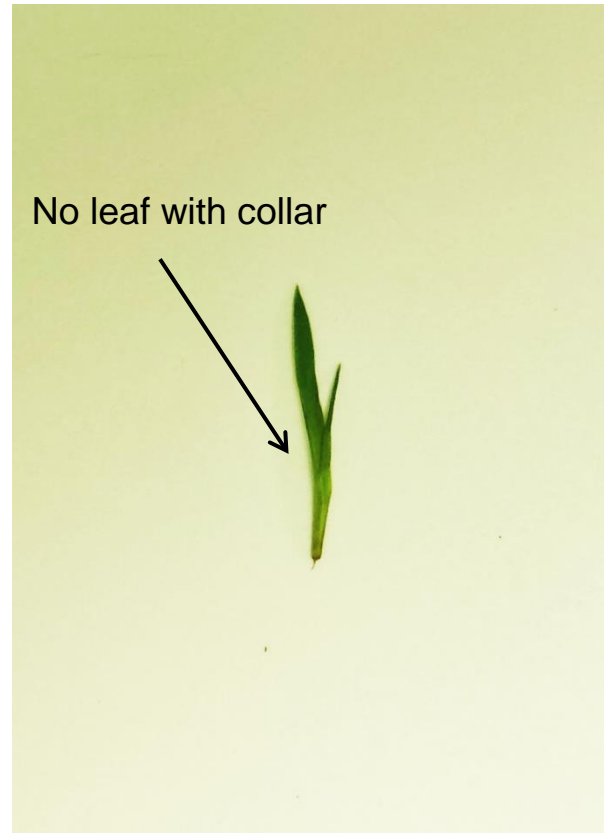


Timothy developmental stages: Adapted from Moore, K.J., L. E. Moser, K.P. Vogel, S.S. Waller, B.E. Johnson and J.F. Pedersen. 1991. Describing and quantifying growth stages of perennial forage grasses. *Agronomy Journal* 83: 1073-1077.

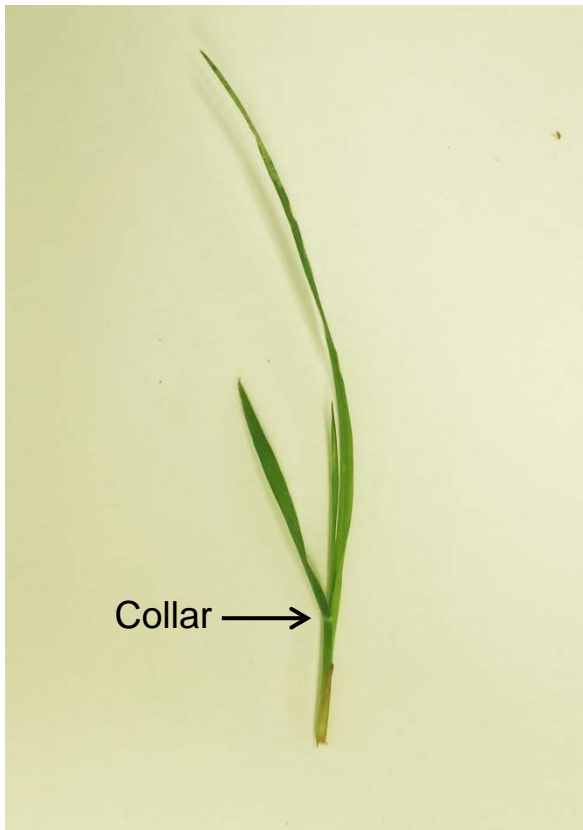
# 1. Vegetative

## VE or V0 (index 1.0)

- Emergence of the first leaf
- No leaf with collar



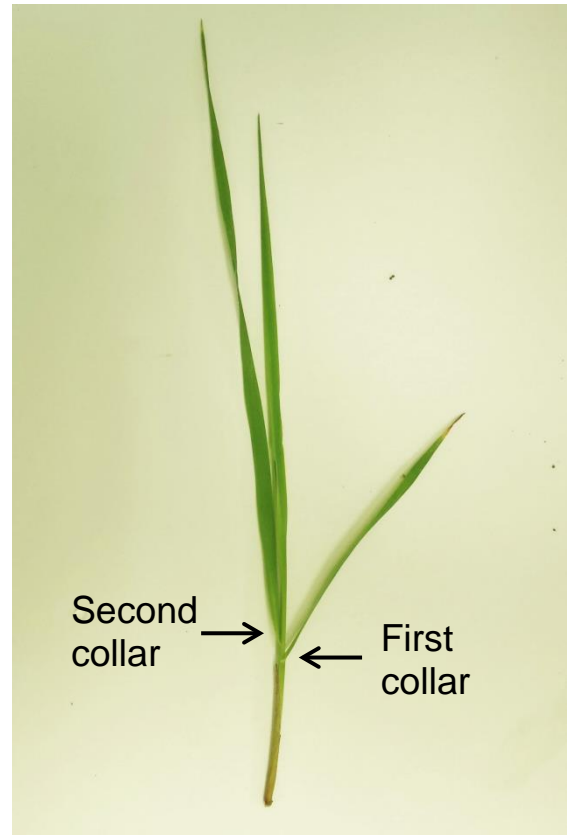
## V1 (index 1.1)



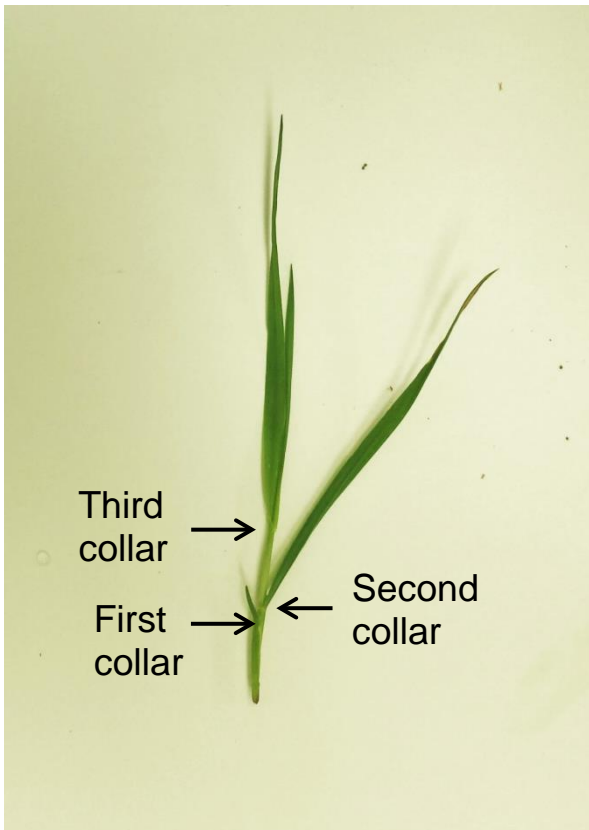
- First leaf with collar

### V2 (index 1.3)

- Second leaf with collar
- No elongation between collars



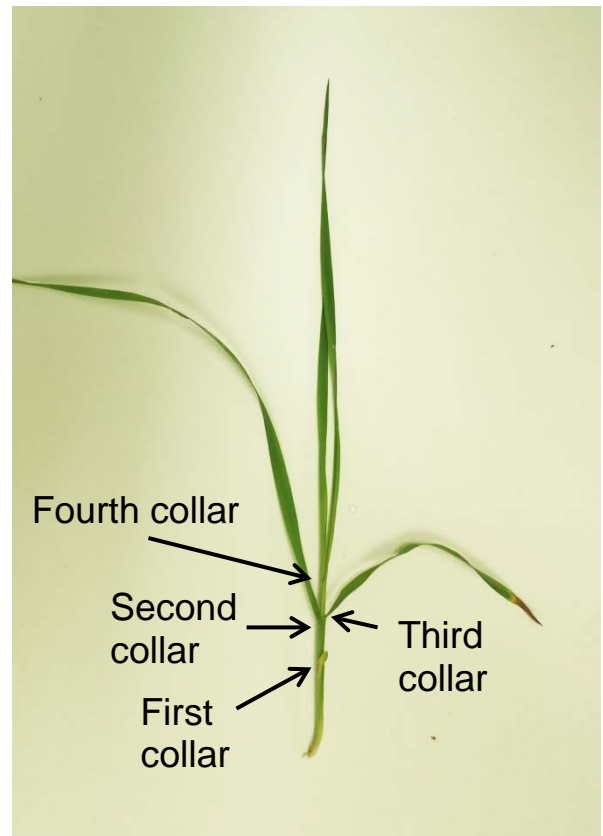
### V3 (index 1.5)



- Third leaf with collar
- No elongation between collars

### V4 (index 1.7)

- Fourth leaf with collar
- No elongation between collars



### V5 (index 1.9)

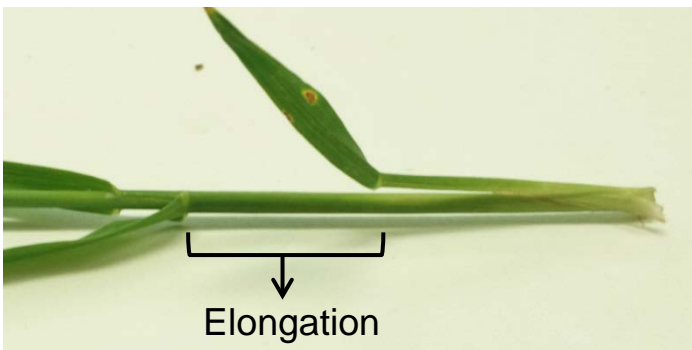
- Fifth leaf with collar
- No elongation between collars



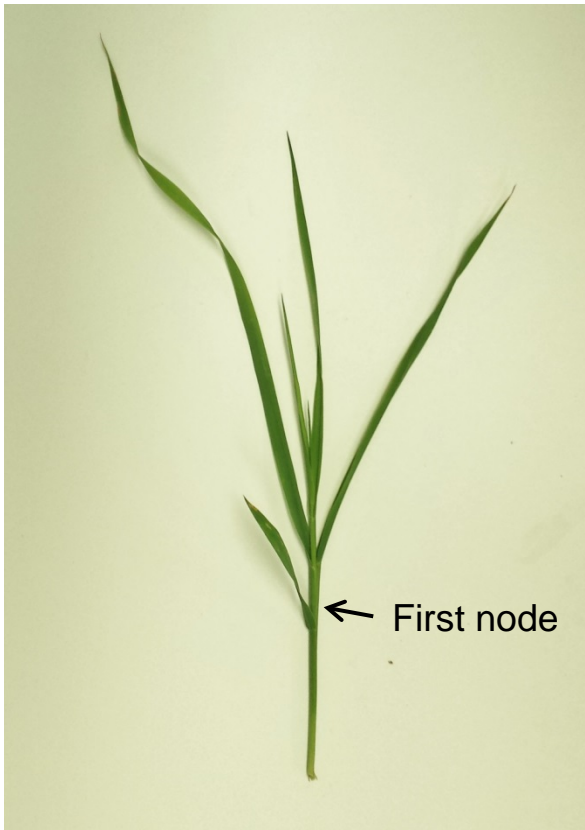
## 2. Stem elongation

### E0 (index 2.0)

- Beginning of the elongation between collars
- Variable number of collars



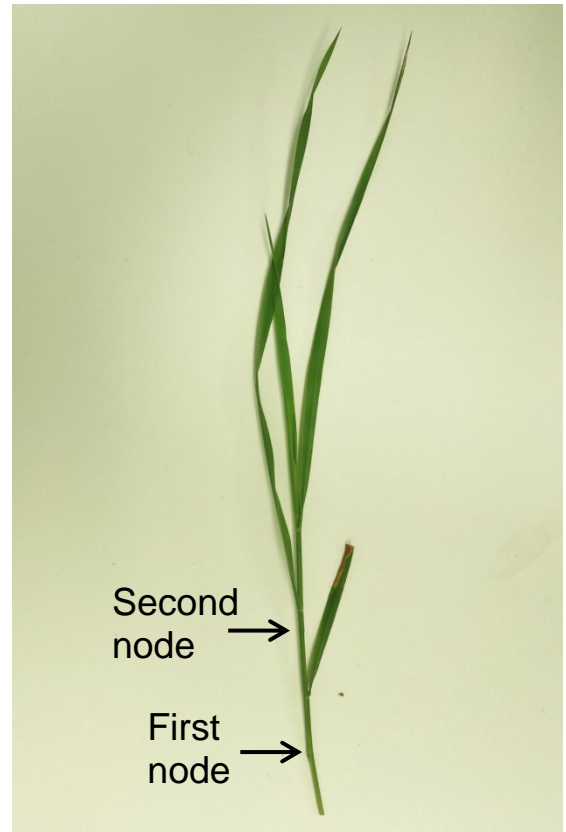
### E1 (index 2.1)



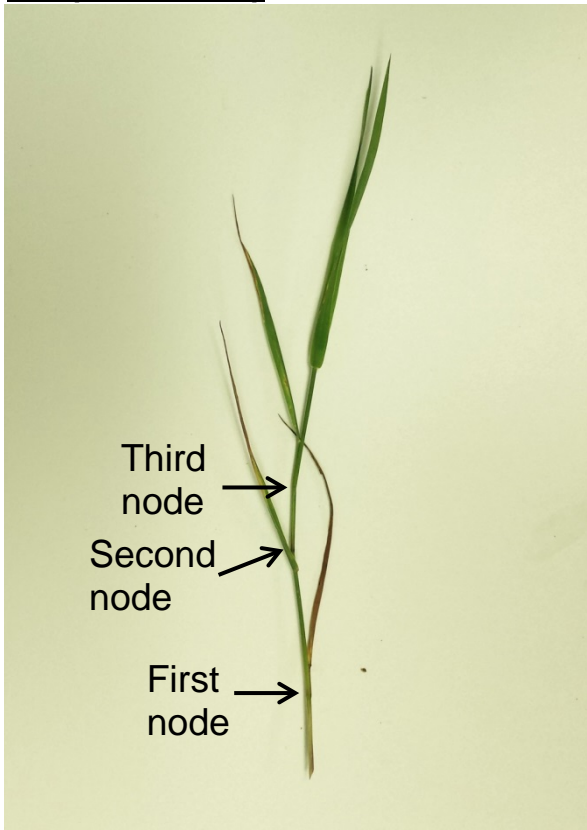
- First palpable or visible node

## E2 (index 2.3)

- Second palpable or visible node



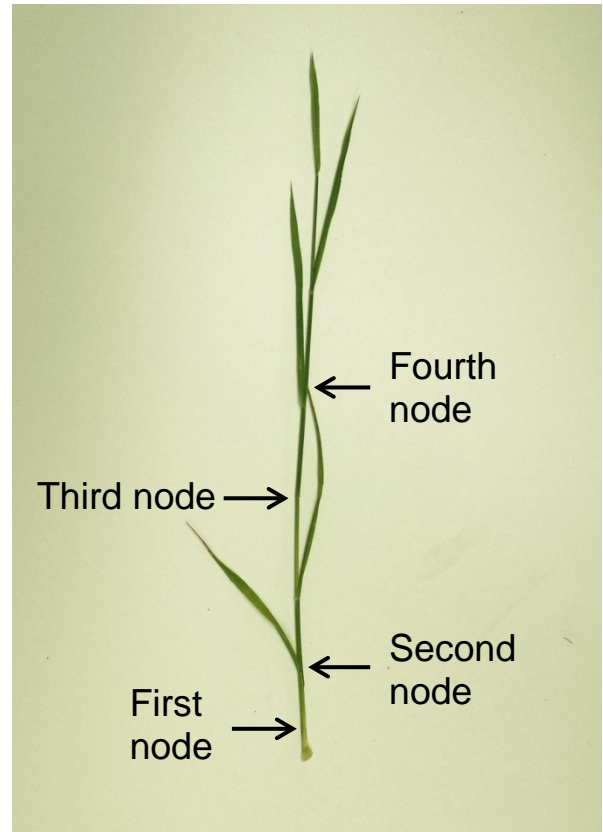
## E3 (index 2.5)



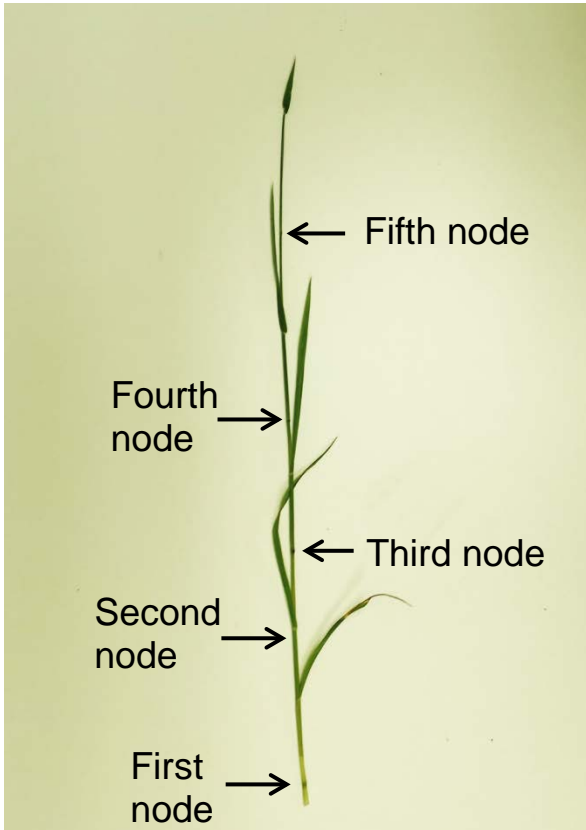
- Third palpable or visible node
- No swelling at the apex

### E4 (index 2.7)

- Fourth palpable or visible node
- No swelling at the apex



### E5 (index 2.9)

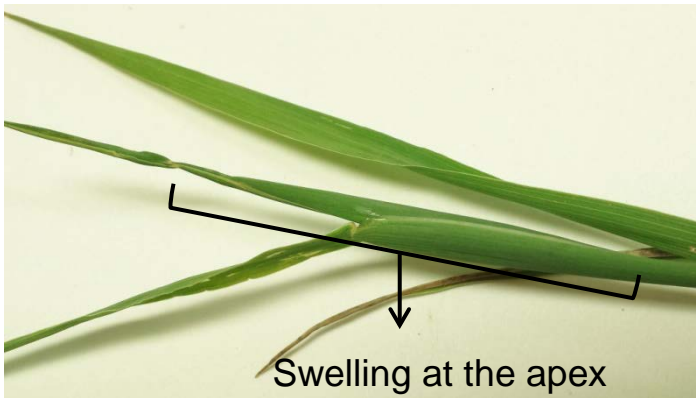


- Fifth palpable or visible node
- No swelling at the apex

### 3. Reproductive

#### R0 (index 3.0)

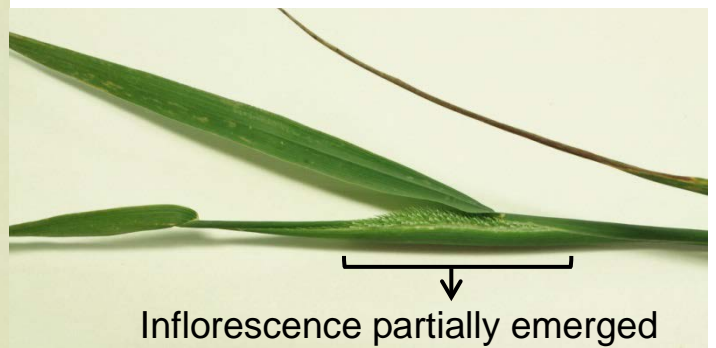
- Swelling at the apex
- Inflorescence not visible



#### R1 (index 3.1)

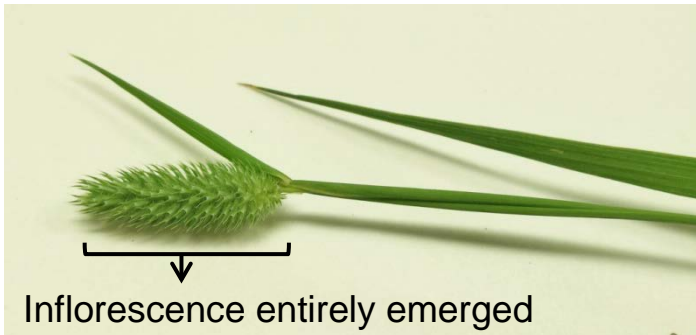


- Emergence of the inflorescence
  - Partially visible



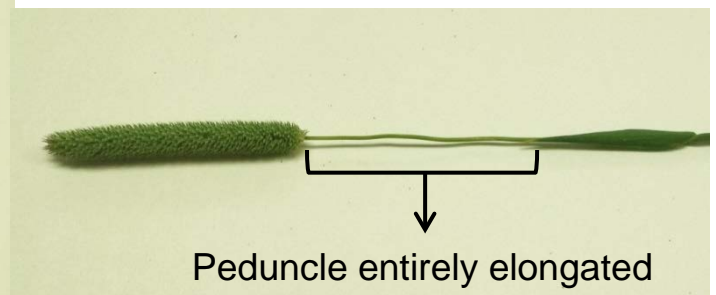
## R2 (index 3.3)

- Inflorescence entirely emerged
- Peduncle not visible



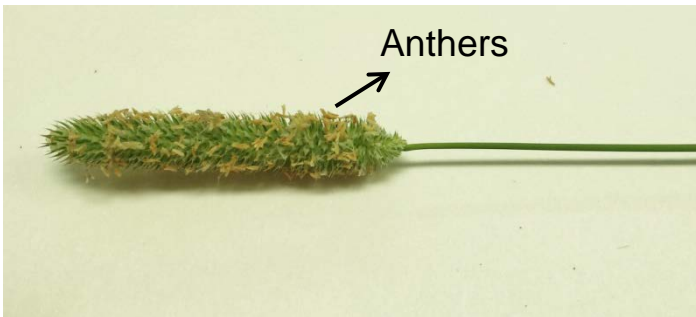
## R3 (index 3.5)

- Inflorescence entirely emerged
- Peduncle entirely elongated



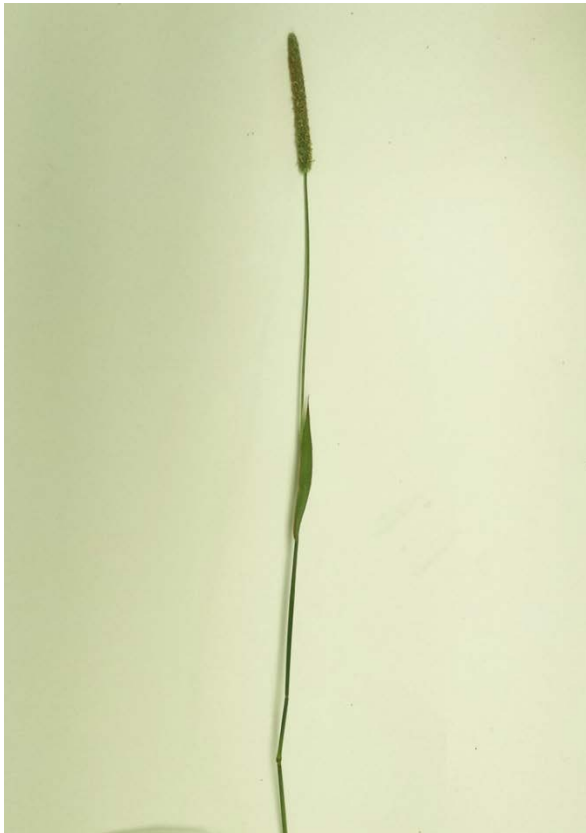
## R4 (index 3.7)

- Anthesis
  - Emergence of the anthers



## R5 (index 3.9)

- Post-anthesis
  - Fertilization



# Alfalfa developmental stages

|                               | Stage            |       | Characteristics                     |
|-------------------------------|------------------|-------|-------------------------------------|
|                               | Name             | Index |                                     |
| <b>Vegetative</b>             | Early vegetative | 0     | Stem $\leq$ 15 cm                   |
|                               | Mid vegetative   | 1     | 15 cm < stem $\leq$ 30 cm           |
|                               | Late vegetative  | 2     | Stem > 30 cm                        |
| <b>Flower bud development</b> | Early bud        | 3     | 1-2 nodes with buds                 |
|                               | Late bud         | 4     | $\geq$ 3 nodes with buds            |
| <b>Flowering</b>              | Early flower     | 5     | 1-2 nodes with open flowers         |
|                               | Late flower      | 6     | $\geq$ 3 nodes with open flowers    |
| <b>Seed production</b>        | Early seed pods  | 7     | 1-3 nodes with green seed pods      |
|                               | Late seed pods   | 8     | $\geq$ 4 nodes with green seed pods |
|                               | Ripe seed pods   | 9     | Brown seed pods                     |

Alfalfa developmental stages: Adapted from Fick, G.W. and Mueller, S.C. 1989. Alfalfa quality, maturity, and mean stage of development. Department of Agronomy, College of Agricultural and Life Sciences. Cornell University, Information Bulletin 217.



# 1. Vegetative

## Early vegetative (index 0)

- Stem  $\leq 15$  cm
- No bud



## Mid vegetative (index 1)



- $15 \text{ cm} < \text{stem} \leq 30 \text{ cm}$
- No bud



### Late vegetative (index 2)

- Stem > 30 cm
- No bud



### Early bud (index 3)

- At least 1 visible or palpable bud at 1 node
- No open flower

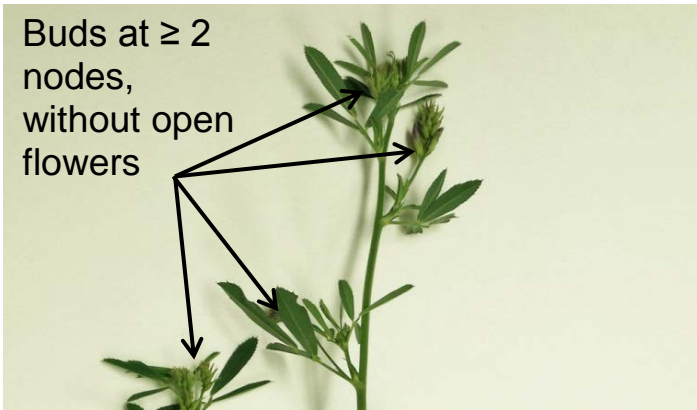


Bud(s) at 1 node



### Late bud (index 4)

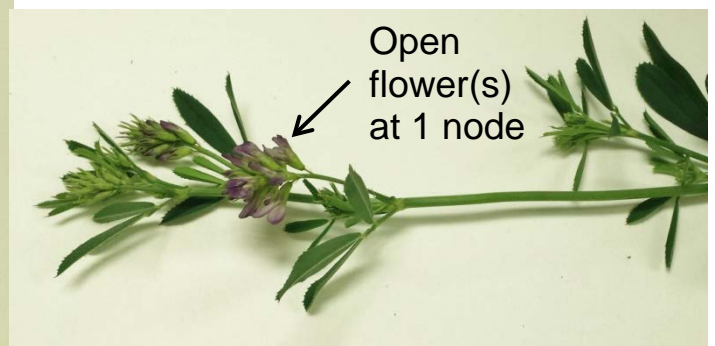
- At least 1 visible or palpable bud at  $\geq 3$  nodes
- No open flower



### Early flower (index 5)



- 1 node with at least 1 open flower
- No seed pod



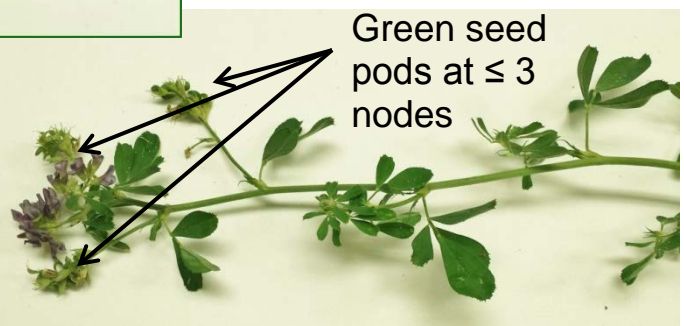
## Late flower (index 6)

- $\geq 2$  nodes with at least 1 open flower
- No seed pods



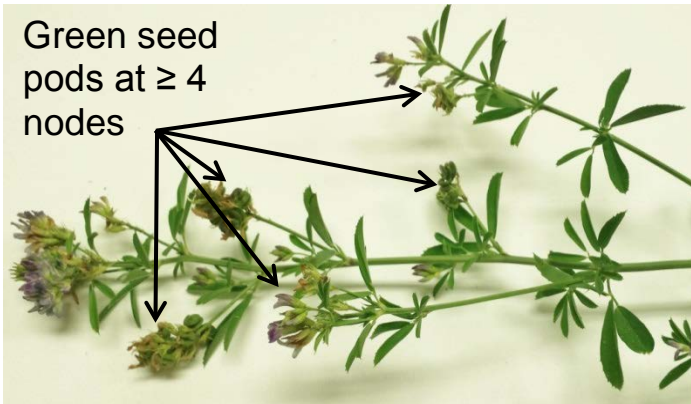
## Early seed pod (index 7)

- $\leq 3$  nodes with at least 1 green seed pod



### Late seed pod (index 8)

- $\geq 4$  nodes with at least 1 green seed pod



### Ripe seed pod (index 9)

- At least 1 node with brown seed pods



# Calculating the mean developmental stage of a sample of timothy or alfalfa

Based on the morphological characteristics previously described (Timothy : Moore et al., 1991; Alfalfa : Fick and Mueller, 1989), we can determine the mean developmental stage of a forage plot based on a sample of 3 or 4 handfuls of entire plants cut at the soil surface, thus of about 40 alfalfa stems or 30 timothy stems.

## Mean Stage by Count (MSC)

1. Separate and count the stems belonging to each developmental stage, thus to each index from 0 to 9 in the case of alfalfa and from 1.0 to 3.9 in the case of timothy (see previous tables).
2. Calculate the Mean Stage by Count of the sample, being the average of the individual stages present in the sample weighted for the proportional number of stems belonging to each stage. We recommend rounding the result to two decimals after the point.

Ex. For a sample of 40 stems of alfalfa having 4 stems in stage 0, 5 stems in stage 1, 5 stems in stage 2, 9 stems in stage 3, 15 stems in stage 4, and 2 stems in stage 5:

$$MSC = \left(\frac{4}{40} \times 0\right) + \left(\frac{5}{40} \times 1\right) + \left(\frac{5}{40} \times 2\right) + \left(\frac{9}{40} \times 3\right) + \left(\frac{15}{40} \times 4\right) + \left(\frac{2}{40} \times 5\right) = 2.80$$

Ex. For a sample of 30 timothy stems having 2 stems in stage 1.1, 4 stems in stage 1.3, 6 stems in stage 1.5, 2 stems in stage 1.7, 12 stems in stage 2.0, and 4 stems in stage 2.1:

$$MSC = \left(\frac{2}{30} \times 1.1\right) + \left(\frac{4}{30} \times 1.3\right) + \left(\frac{6}{30} \times 1.5\right) + \left(\frac{2}{30} \times 1.7\right) + \left(\frac{12}{30} \times 2.0\right) + \left(\frac{4}{30} \times 2.1\right) = 1.67$$



## Mean Stage by Weight (MSW)

1. Separate the stems belonging to each developmental stage, thus to each index from 0 to 9 in the case of alfalfa and from 1.0 to 3.9 in the case of timothy (see previous tables).
2. Dry the stems at about 55-65°C for at least 48 h, until they reach a constant weight, then record the weight of each sample (weight of the bag and its content minus the weight of the bag when empty).
3. Calculate the sample Mean Stage by Weight, being the average of the individual stages present in the sample weighed for the proportional weight of stems belonging to each stage.

The MSW is calculated the same way as the MSC, except that the dry weight of stems, instead of the number, in each stage is multiplied by the stage index. We recommend rounding the result to two decimals after the point.

Ex. For an alfalfa sample having 4 stems in stage 0 weighing 0.3 g, 5 stems in stage 1 weighing 0.7 g, 5 stems in stage 2 weighing 1.9 g, 9 stems in stage 3 weighing 7.0 g, 15 stems in stage 4 weighing 36.1 g, and 2 stems in stage five weighing 6.2 g:

$$MSW = \left(\frac{0.3}{52.2} \times 0\right) + \left(\frac{0.7}{52.2} \times 1\right) + \left(\frac{1.9}{52.2} \times 2\right) + \left(\frac{7.0}{52.2} \times 3\right) + \left(\frac{36.1}{52.2} \times 4\right) + \left(\frac{6.2}{52.2} \times 5\right) = 3.85$$

Ex. For a timothy sample having 2 stems in stage 1.1 weighing 0.1 g, 4 stems in stage 1.3 weighing 0.2 g, 6 stems in stage 1.5 weighing 0.3 g, 2 stems in stage 1.7 weighing 0.2 g, 12 stems in stage 2.0 weighing 1.8 g, and 4 stems in stage 2.1 weighing 1.6 g:

$$MSW = \left(\frac{0.1}{4.2} \times 1.1\right) + \left(\frac{0.2}{4.2} \times 1.3\right) + \left(\frac{0.3}{4.2} \times 1.5\right) + \left(\frac{0.2}{4.2} \times 1.7\right) + \left(\frac{1.8}{4.2} \times 2.0\right) + \left(\frac{1.6}{4.2} \times 2.1\right) = 1.93$$



## Acknowledgement

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