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Developmental stages of timothy and alfalfa

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Canada

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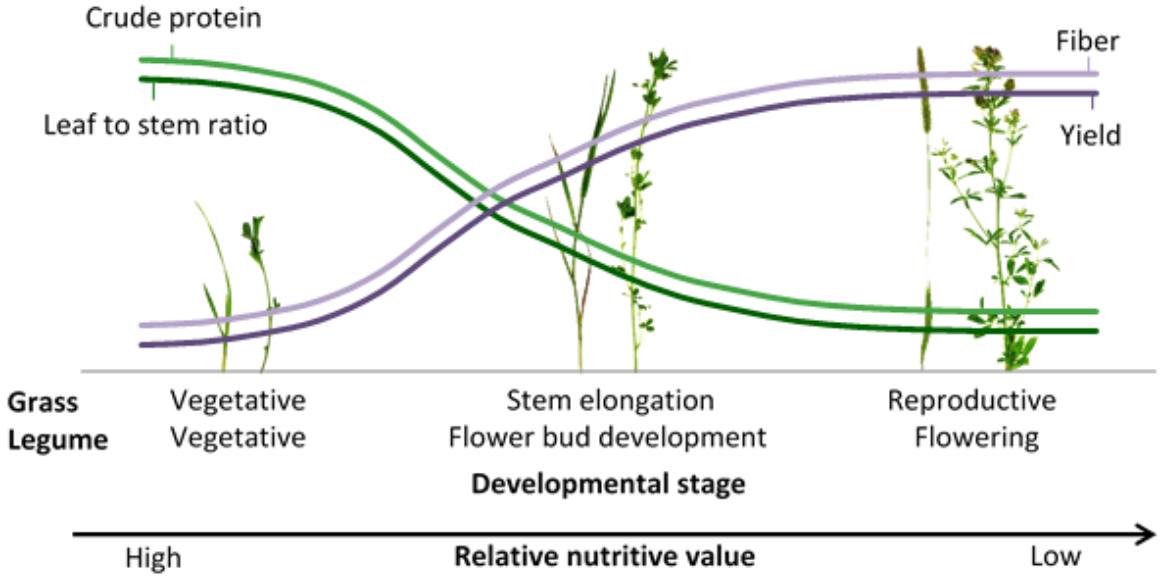
Foreword

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).

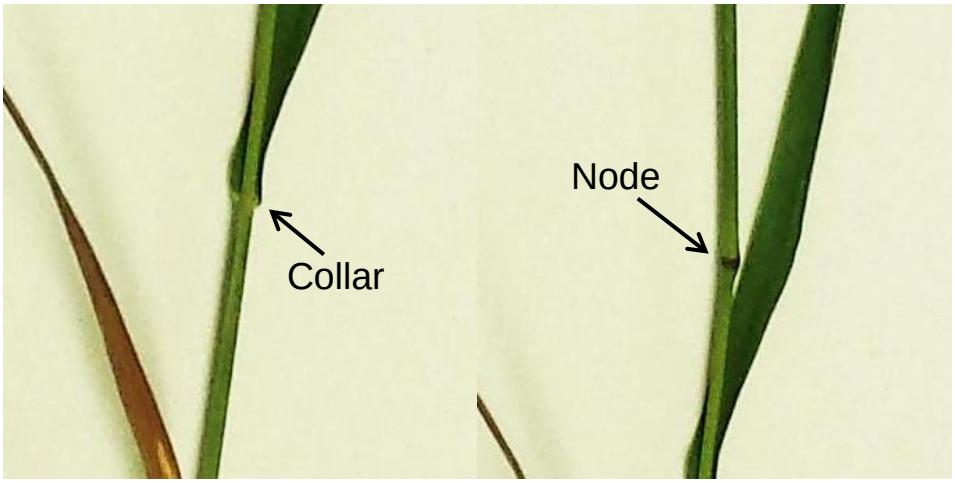
Effects of the developmental stage of plants on their yield and nutritive value.



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

Timothy developmental stages

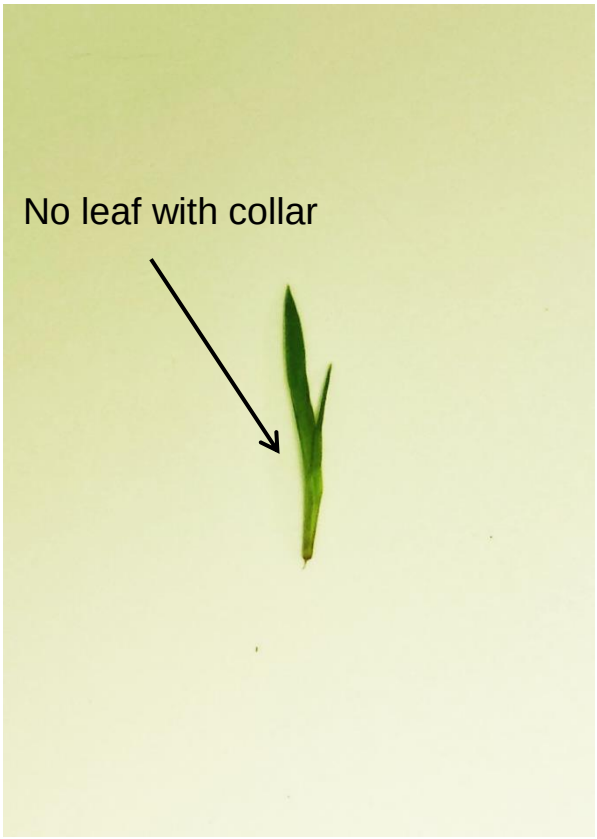
	Stage		Characteristics
	Name	**Index**	
Vegetative (foliar development)	V0 (VE)	1.0	Emergence of the first leaf
	V1	1.1	First leaf with collar
	V2	1.3	Second leaf with collar
	V3	1.5	Third leaf with collar
	V4	1.7	Fourth leaf with collar
	V5	1.9	Fifth leaf with collar
Stem elongation	E0	2.0	Elongation 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
Reproductive (inflorescence development)	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.

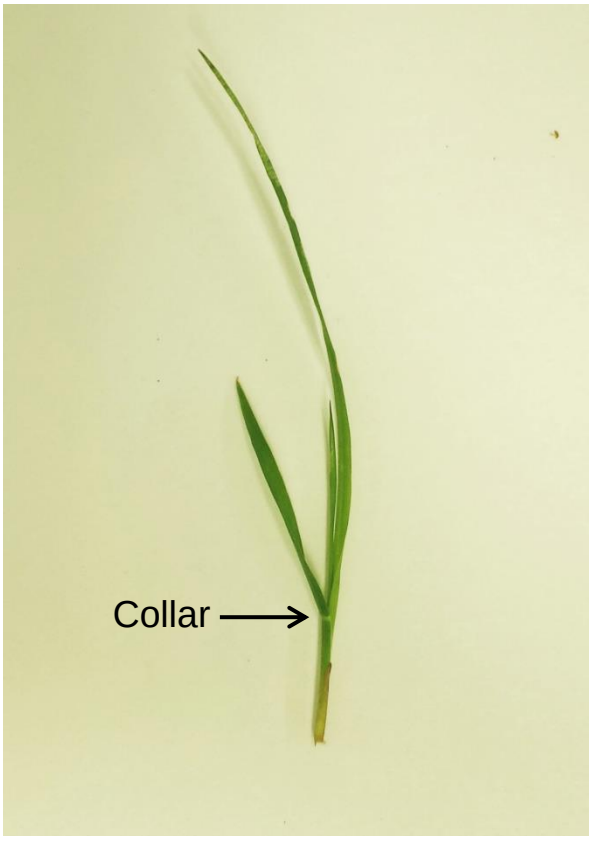
1. Vegetative

VE or V0 (index 1.0)



- Emergence of the first leaf
- No leaf with collar

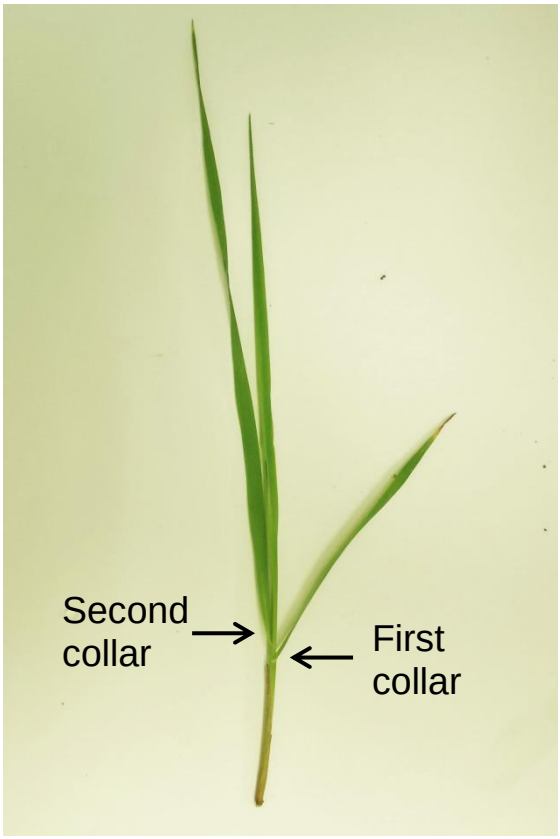
V1 (index 1.1)



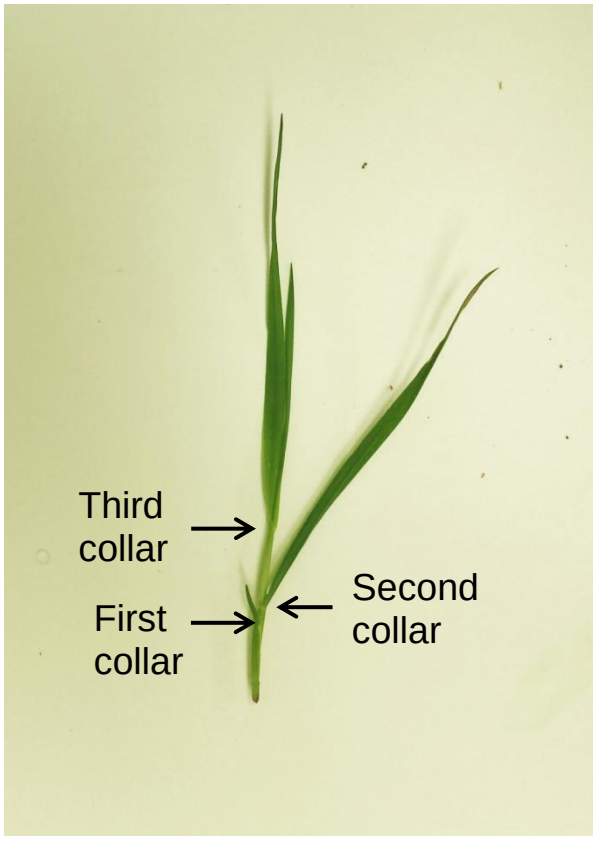
- First leaf with collar

V2 (index 1.3)

- Second leaf with collar
- No elongation between collars



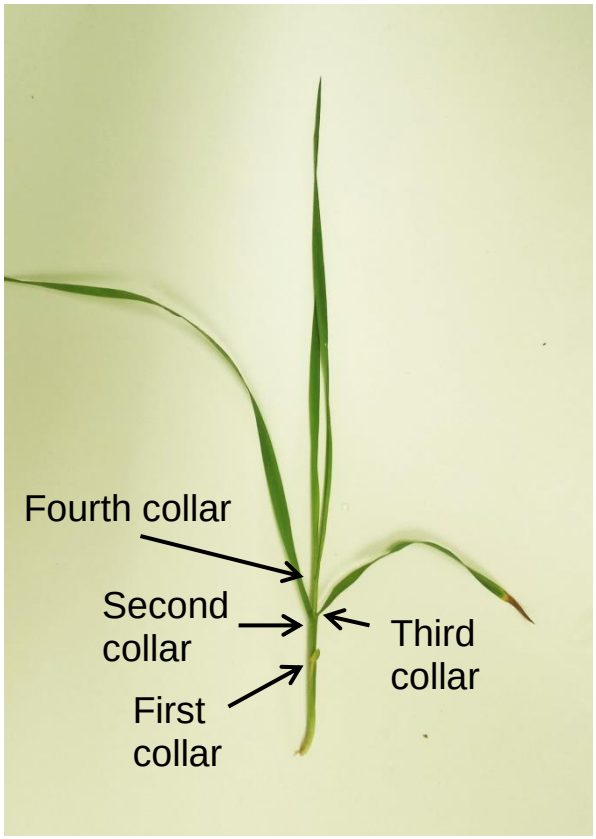
V3 (index 1.5)



- Third leaf with collar
- No elongation between collars

V4 (index 1.7)

- Fourth leaf with collar
- No elongation between collars



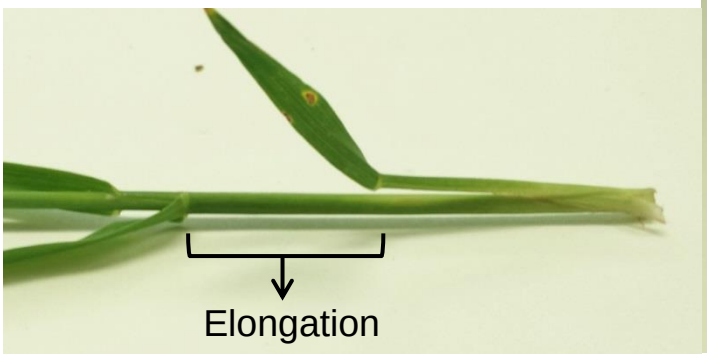
V5 (index 1.9)

- Fifth leaf with collar
- No elongation between collars

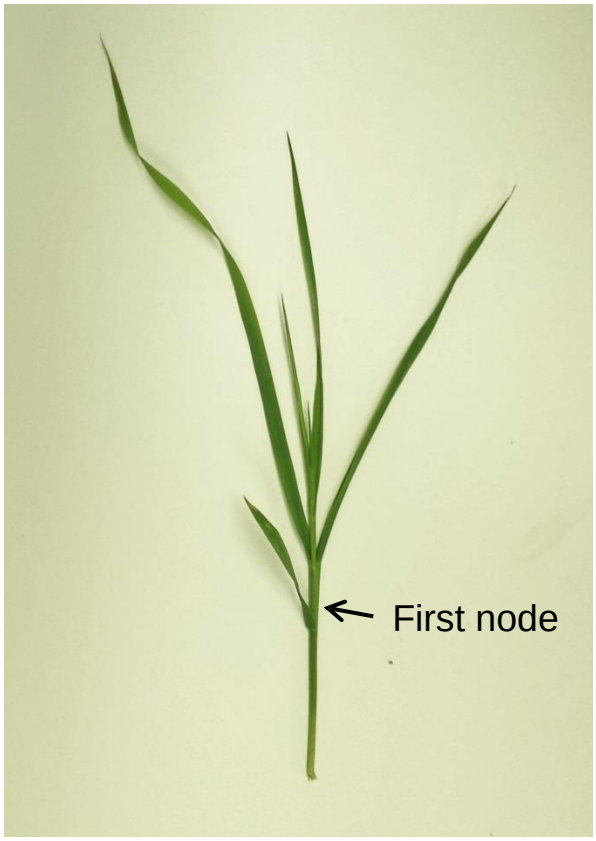
2. Stem elongation

E0 (index 2.0)

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



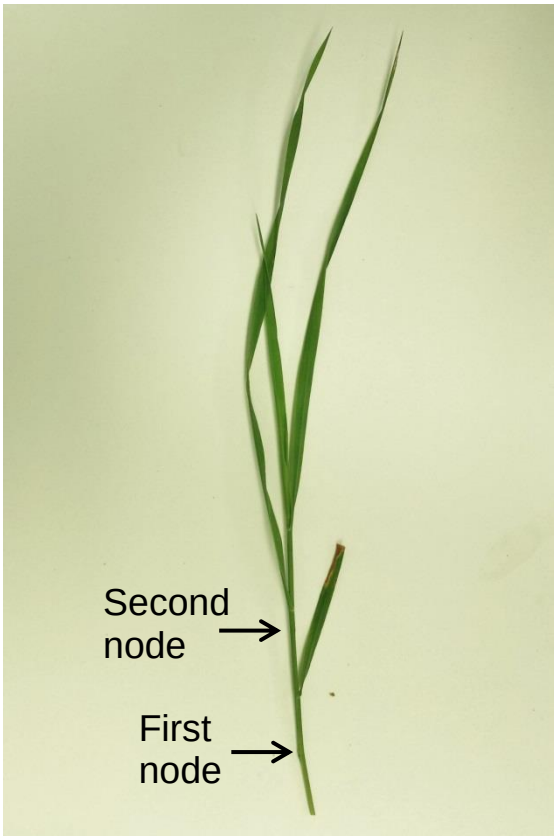
E1 (index 2.1)



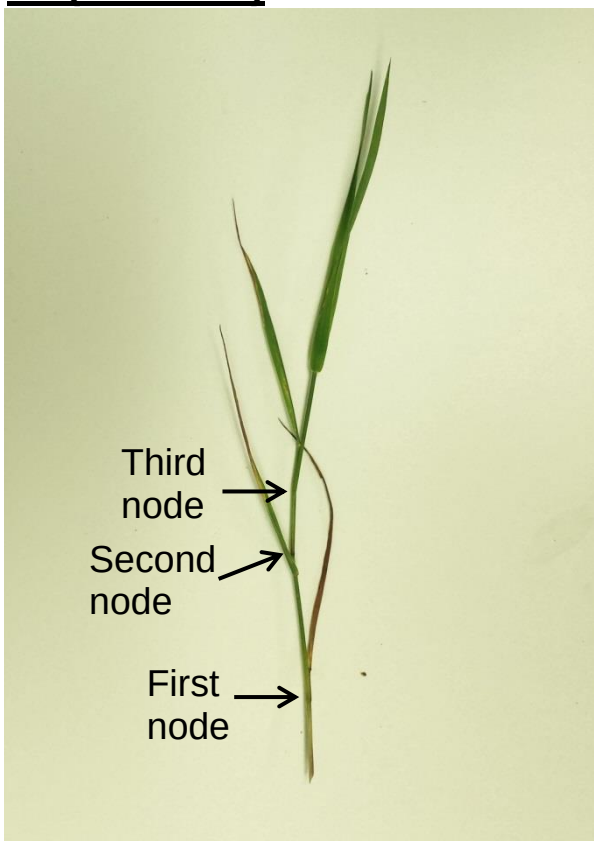
- First palpable or visible node

E2 (index 2.3)

- Second palpable or visible node



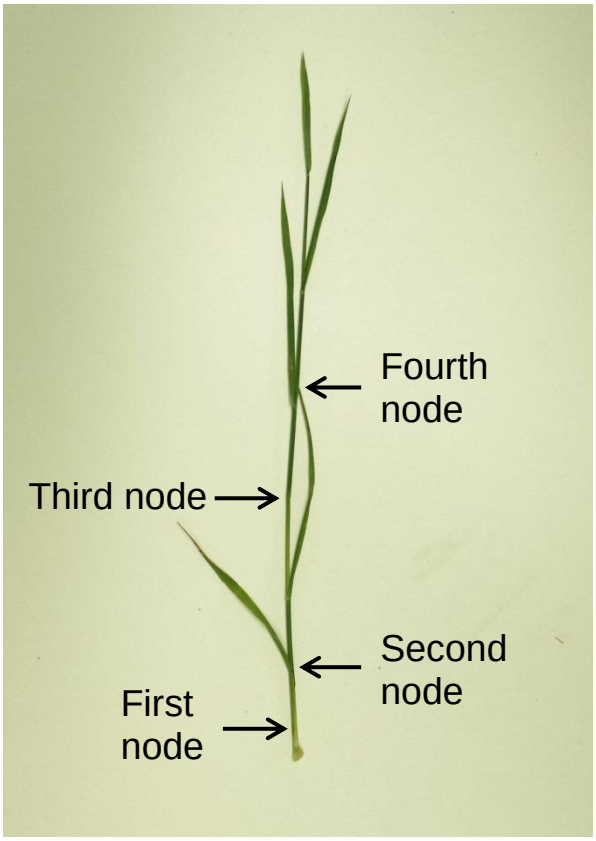
E3 (index 2.5)



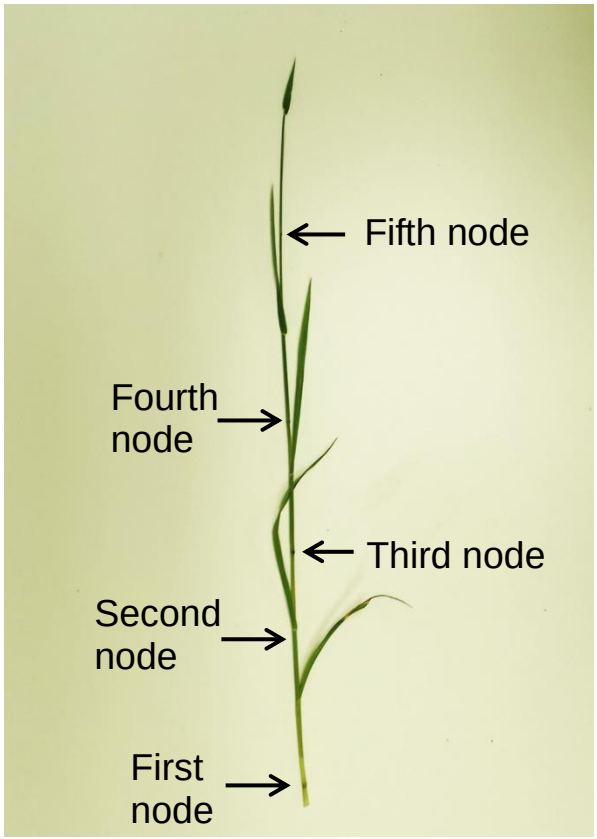
- Third palpable or visible node
- No swelling at the apex

E4 (index 2.7)

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



E5 (index 2.9)

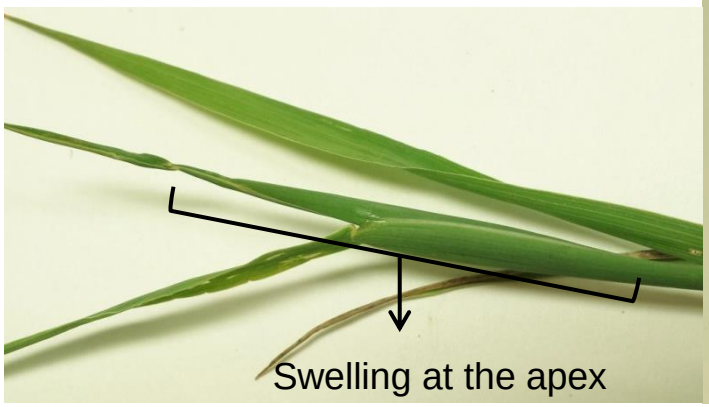


- Fifth palpable or visible node
- No swelling at the apex

3. Reproductive

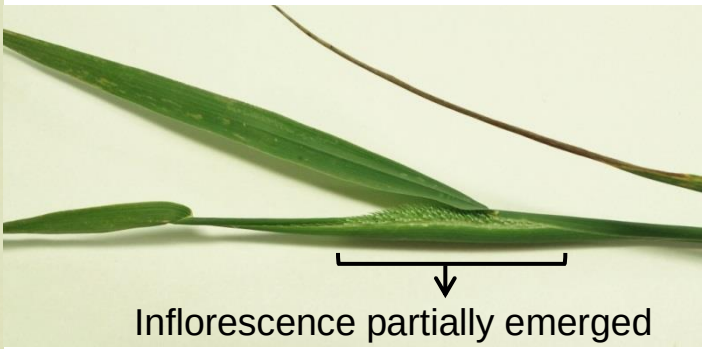
R0 (index 3.0)

- Swelling at the apex
- Inflorescence not visible



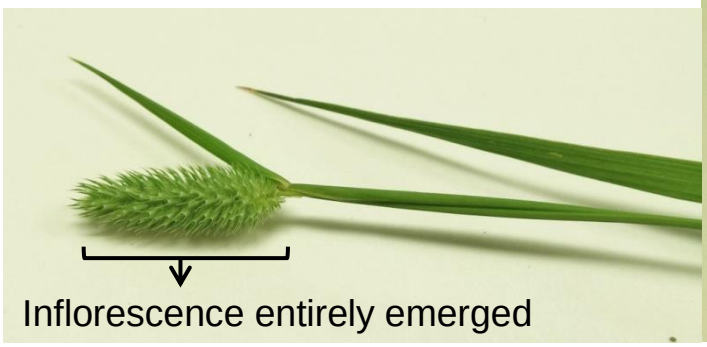
R1 (index 3.1)

- Emergence of the inflorescence
    - Partially visible



R2 (index 3.3)

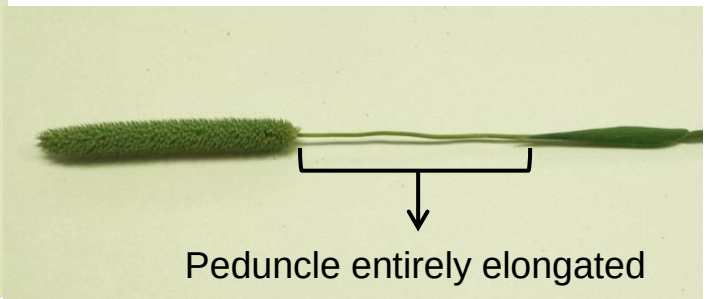
- Inflorescence entirely emerged
- Peduncle not visible



Inflorescence entirely emerged

R3 (index 3.5)

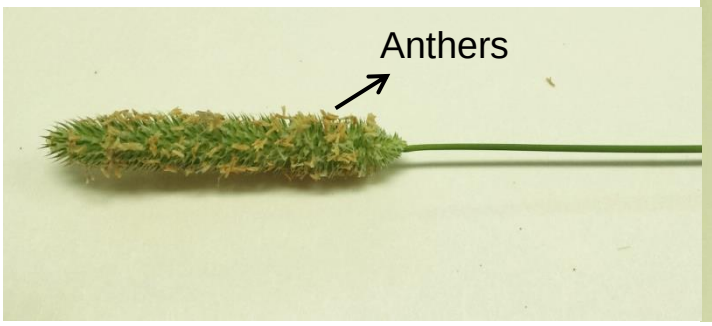
- Inflorescence entirely emerged
- Peduncle entirely elongated



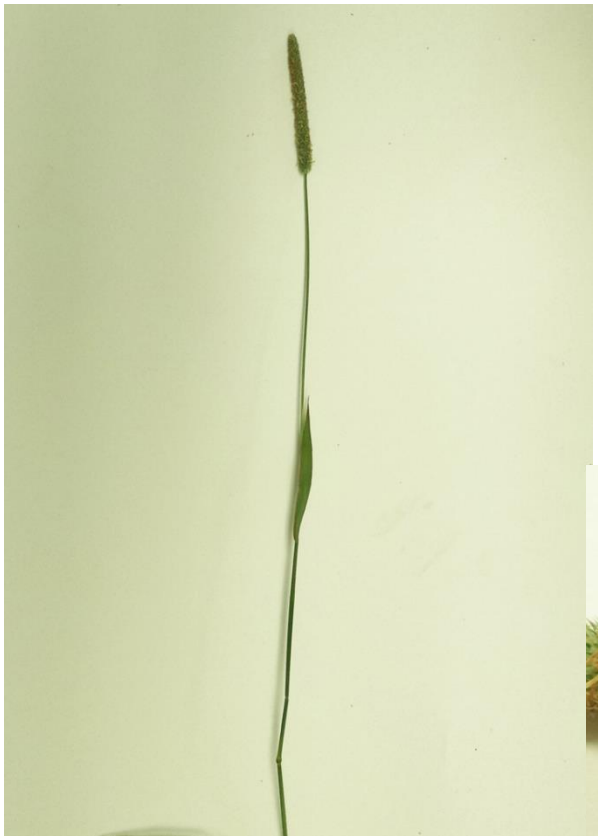
Peduncle entirely elongated

R4 (index 3.7)

- Anthesis
    - Emergence of the anthers



R5 (index 3.9)



- Post-anthesis
    - Fertilization

Alfalfa developmental stages

	Stage		Characteristics
	Name	**Index**	
Vegetative	Early vegetative	0	Stem ≤ 15 cm
	Mid vegetative	1	15 cm < stem ≤ 30 cm
	Late vegetative	2	Stem > 30 cm
Flower bud development	Early bud	3	1-2 nodes with buds
	Late bud	4	≥ 3 nodes with buds
Flowering	Early flower	5	1-2 nodes with open flowers
	Late flower	6	≥ 3 nodes with open flowers
Seed production	Early seed pods	7	1-3 nodes with green seed pods
	Late seed pods	8	≥ 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)

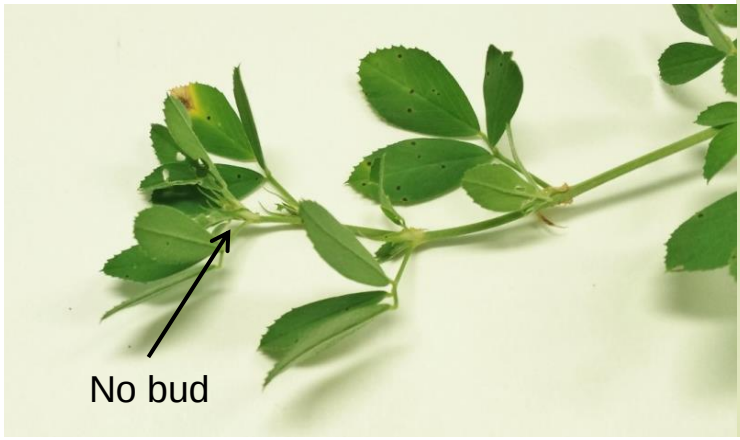
- Stem ≤ 15 cm
- No bud

Mid vegetative (index 1)

- 15 cm < stem ≤ 30 cm
- No bud

Late vegetative (index 2)

- Stem > 30 cm
- No bud

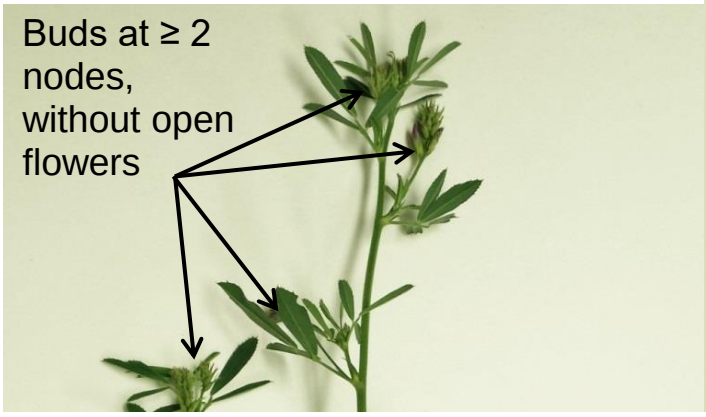


Early bud (index 3)

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

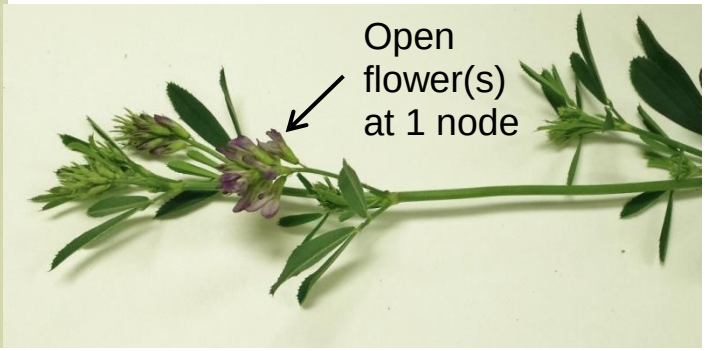
Late bud (index 4)

- At least 1 visible or palpable bud at ≥ 2 nodes
- No open flower



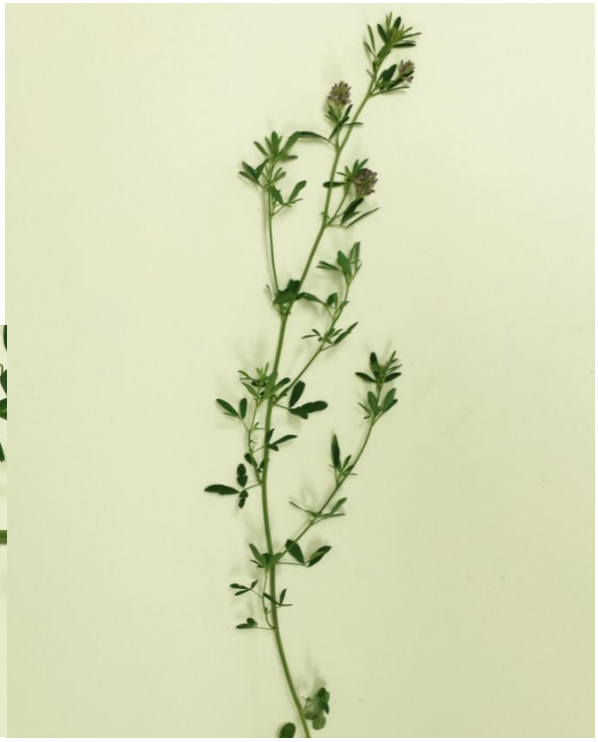
Early flower (index 5)

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

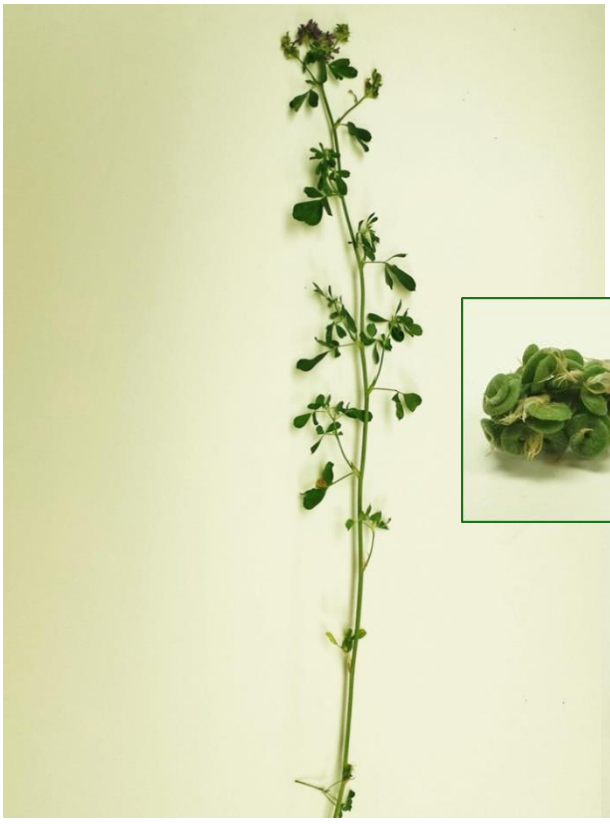


Late flower (index 6)

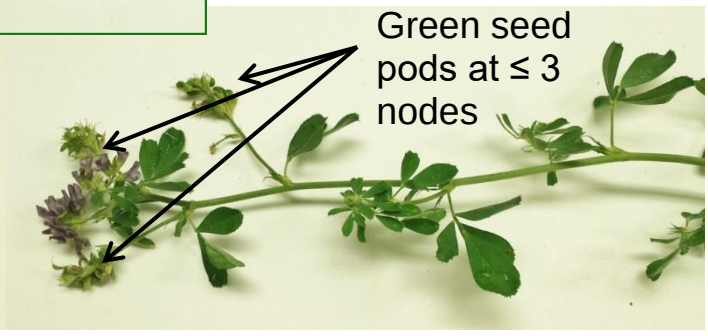
- ≥ 2 nodes with at least 1 open flower
- No seed pods



Early seed pod (index 7)

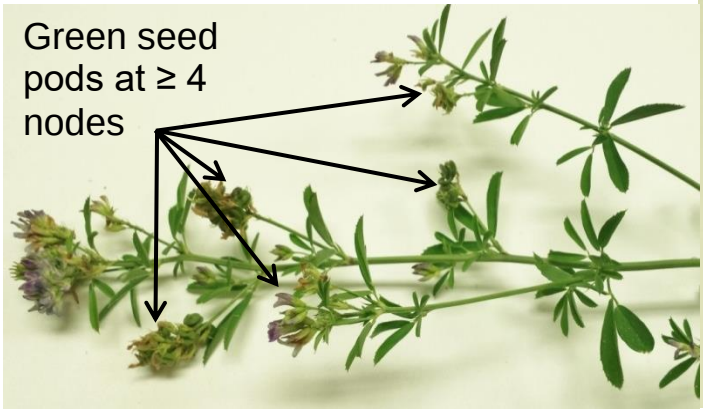


- ≤ 3 nodes with at least 1 green seed pod



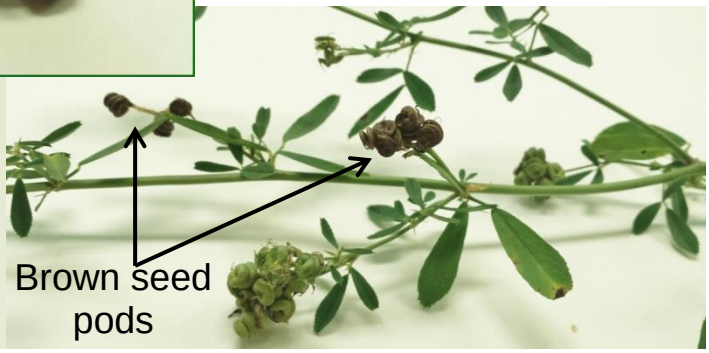
Late seed pod (index 8)

- 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:

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

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:

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

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 weighting 7.0 g, 15 stems in stage 4 weighing 36.1 g, and 2 stems in stage five weighing 6.2 g:

$$MSW=(\frac{0.3}{52.2}\times0)+(\frac{0.7}{52.2}\times1)+(\frac{1.9}{52.2}\times2)+(\frac{7.0}{52.2}\times3)+(\frac{36.1}{52.2}\times4)+(\frac{6.2}{52.2}\times5)=3.85$$

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:

$$MSW=(\frac{0.1}{4.2}\times1.1)+(\frac{0.2}{4.2}\times1.3)+(\frac{0.3}{4.2}\times1.5)+(\frac{0.2}{4.2}\times1.7)+(\frac{1.8}{4.2}\times2.0)+(\frac{1.6}{4.2}\times2.1)=1.93$$

Acknowledgement

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