Autecology of Green Needlegrass on the Northern Mixed Grass Prairie

Llewellyn L. Manske PhD
Research Professor of Range Science
North Dakota State University
Dickinson Research Extension Center
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The autecology of Green needlegrass, *Nassella viridula*, is one of the prairie plant species included in a long ecological study conducted at the NDSU Dickinson Research Extension Center during 67 growing seasons from 1946 to 2012 that quantitatively describes the changes in growth and development during the annual growing season life history and the changes in abundance through time as affected by management treatments for the intended purpose of the development and establishment of scientific standards for proper management of native rangelands of the Northern Plains. The introduction to this study can be found in report DREC 16-1093 (Manske 2016).

Green needlegrass, *Nassella viridula* (Trin.) Barkworth, is a member of the grass family, Poaceae, tribe, Stipeae, Syn.: *Stipa viridula* Trin., and is a native, long lived perennial, monocot, cool-season, mid grass, that is drought and cold tolerant, disease resistant, moderately tolerant of flooding, and has a weak tolerance to shade. The first North Dakota record is Moran 1937. Early aerial growth consists of basal leaves arising from crown tiller buds. Basal leaf blades are 20-50 cm (8-20 in) long, 2-5.5 mm wide, tapering to a threadlike tip, with many prominent ridges on upper surface. Leaves roll inward when dry. The split sheath has overlapping margins and long soft hairs at the top of the throat. The narrow collar is continuous and has long hairs at the margins. The membranous ligule is 1–2 mm long, with a flat entire upper edge. The auricles are absent. The fibrous root system is extensive with the main roots 1 mm thick and well branched. The lateral spread extends 35.6 cm (14 in) in the next 15 cm (6 in) of soil. Abundant rootlets develop on the main roots in the top 76 cm (2.5 ft) of soil. A few long main roots extend downward to 1.5 m (5 ft) deep. Regeneration is primarily asexual propagation by crown tillers. Seedling success is low but better than most native grasses. Flower stalks are erect, 55-100 cm(21.6 -39.4 in) tall with fine, short hairs below the nodes. Inflorescence are dense, compact panicles 10-25 cm (4-10 in) long. The spikelets have one floret with a long slender tip and an attached awn that is twice bent and twisted. Flower period is from early June to mid July. Leaves are highly palatable to livestock. Fire top kills aerial parts and can consume the entire crown when the soil is dry. Fire halts the processes of the four major defoliation resistance mechanisms and causes great reductions in biomass production and tiller density. This summary information on growth development and regeneration of Green needlegrass was based on works of Stevens 1963, Zaczkowski 1972, Dodds 1979, Great Plains Flora Association 1986, Taylor 2001, Knudson 2005, and Johnson and Larson 2007.

Procedures

The 1946-1947 Study

Grass and upland sedge species samples to determine crude protein and phosphorus content were collected weekly during the growing seasons of 1946 and 1947 from two seeded domesticated grasslands and a native rangeland pasture at the Dickinson Research Extension Center located at Dickinson in western North Dakota. Current year's growth of lead tillers of each species was included in the sample; previous year's growth was separated and discarded. Ungrazed samples were collected for each species except for Kentucky bluegrass, which only grew along a watercourse where almost all of the plants had been grazed and remained in an immature vegetative stage, however, a small number of plants escaped grazing and developed normally providing the phenological development data. Crude protein (N X 6.25) content was determined by the procedure outlined in the Official and Tentative Methods of Analysis (A.O.A.C. 1945). Phosphorus content was determined by the method outlined by Bolin and Stamberg (1944). Data were reported as percent of oven-dried weight.

Plant condition by stage of plant development and growth habit was collected for each species on sample dates. These data are reported as phenological growth stage in the current report. The grass nutritional quality and phenological growth data were published in Whitman et al. 1951.

The 1955-1962 Study

Grass and upland sedge tiller growth in height of leaves and stalks were collected from ungrazed plants during the growing seasons of 1955-1962. Basal leaves were measured from ground level to the tip of the extended leaves. Culm leaves were measured from ground level to the apex of the uppermost leaf. Stalk measurements were from ground levels to the tip of the stalk or to the tip of the inflorescence after it had developed. An average of 10 plants of each species were measured at approximate 7 to 10 day intervals from early May until early September. In addition, phenological growth stages were recorded to include stalk initiation, head emergence, flowering (anthesis), seed development, seed maturity, earliest seed shedding, and an estimation of percent of leaf dry in relation to total leaf area. The grass growth in height and phenological data were reported in Goetz 1963.

The 1964-1969 Study

Phenological data of grass and upland sedge at anthesis stage was determined by recording observation dates. Leaf senescence by date was determined as an estimation of percentage of dry leaf in relation to total leaf area. Grass and upland sedge tiller growth in height of leaves were collected from ungrazed plants during the growing seasons of 1964-1966. Basal leaves were measured from ground level to the tip of the extended leaf. Culm leaves were measured from ground level to the apex of the uppermost leaf. An average of 20 plants at approximately 7 to 10 day intervals during the growing season from mid April to late August from control treatment on sandy, silty, overflow, and thin claypan ecological sites. Phenological data of anthesis stage, leaf senescence, and growth in leaf height were reported in Goetz 1970. Crude protein content of grasses and upland sedges was determined from a composite of 10 samples of each species collected systematically at biweekly intervals from mid May to early September, 1964-1969 on sandy, silty, overflow, and thin claypan ecological sites. Plant material was oven dried at 105°F. Analysis of the samples were made by the Cereal Technology Department, North Dakota State University, using standard crude protein determinations and reported in Goetz 1975.

The 1969-1971 Study

The range of flowering time of grasses and upland sedges were determined by recording daily observations of plants at anthesis on several prairie habitat type collection locations distributed throughout 4,569 square miles of southwestern North Dakota. The daily observed flowering plant data collected during the growing seasons of 1969 to 1971 from April to August were reported as flower sample periods with 7 to 8 day duration in Zaczkowski 1972.

Results

Green needlegrass increases growth activity shortly after snow melt. Leaf growth in cool season grasses continues very slowly during the entire winter. The top portion of these carryover leaves become exposed to low temperatures causing the cell walls to rupture. The lower portion of the carryover leaves have intact cell walls and regreen with active chlorophyll when liquid water becomes available in the soil for at least during the daylight hours. The green portion of the carryover leaves provide a large quantity of carbohydrates and fixed energy used in the production of new leaves. Growth of new leaves of Green needlegrass is visible by 13 April (tables 1). All native cool season grasses produce 3.5 new leaves at or shortly after 1 June, when lead tillers are physiologically capable of positive response to partial defoliation of 25% to 33% of leaf weight by graminivores. On 1 June, the tallest leaf has reached 66% of maximum leaf height (table 2). The flower stalk reaches the boot stage between 16 and 26 May, head emergence is reached around 12 June, and the flower (anthesis) stage is reached between 28 May and 16 June with the 5 week flower period from early June to mid July (tables 1, 3, 4, and 5). Lead tiller crude protein content is 23.5% at boot stage, 18.0% at head emergence and flower stage (table 1). Leaf growth is rapid during June reaching maximum height on 22 June (table 2). Seed stalks reach maximum height on 29 June and still contain 14.4% crude protein (tables 1 and 3). Seeds are developing between 13 June and 2 July, seeds are being shed between 12 and 16 July, and lead tillers drop below the crude protein requirements of lactating cows at the end of July (tables 1, 5, and 6). Leaf dryness starts on 29 July and continues through August into September (tables 1 and 5). Lead tillers drop below the phosphorus requirements of lactating cows in mid August (tables 1 and 6). Green needlegrass tillers growing on the overflow ecological site tend to produce taller leaf height after late May, have about the same rate of leaf dryness, and have greatly reduced crude protein content during the entire growing season than tillers growing on silty ecological sites (tables 7, 8, and 9). Unless grazing management practice has properly manipulated the stimulation of an adequate quantity of Green needlegrass vegetative secondary tillers, lactating

cows will be grazing forage below their crude protein requirements after late July.

Discussion

Green needlegrass, *Nessella viridula*, is a native, long-lived perennial, cool season, mid grass, monocot, of the grass family that is common on healthy mixed grass prairie plant communities. Green needlegrass generally grows on medium to fine textured soils of loams to clay loams on silty and overflow ecological sites. Mixed grass prairie areas that the climate is semi arid with evapotranspiration greater than precipitation, Green needlegrass tends to grow on sites that receive some additional water as runin moisture. When Green needlegrass has sufficient spacing, the plants become robust, however, when other native grass species densities increase and encroach upon the Green needlegrass plants, Green needlegrass densities decrease. Green needlegrass is drought and cold tolerant, disease resistant, moderately tolerant of flooding for short periods, and has a weak tolerance to shade. The drought tolerance of Green needlegrass is greatly inferior to the drought tolerance of Needle and thread.

Green needlegrass tillers live for two growing seasons. Early season activity starts by regreening with active chlorophyll in the portions of the carryover leaves that have intact cell walls from the previous growing season vegetative tillers and fall tillers. The green portion of the carryover leaves provides large quantities of carbohydrates and fixed energy for the production of new leaves. Growth of new leaves of Green needlegrass are visible between 8 and 13 April. Green needlegrass lead tillers are derived from carryover vegetative tillers and produces 3.5 new leaves on or near 1 June. Lead tillers at the 3.5 new leaf stage are physiologically capable of positive response to partial defoliation of 25% to 33% of leaf weight by graminivores. The tallest leaf is at 66.0% of maximum height on 1 June and the lead tiller contains 17.9% crude protein and 0.262% phosphorus on silty ecological sites during early June. The flower stalks reach the boot stage around 16 to 26 May and reach the flower stage around 28 May to 16 June, with a five week flower period from early June to mid July. Some Green needlegrass flower heads are cleistogamous and exposed flower parts are rarely observed. Leaf growth and stalk growth in height is rapid during June and both reach maximum height during late June when lead tillers contain 14.4% crude protein. Seeds are developing between 13 June and 2 July, seeds are being shed between 12 and 16 July, and lead tillers drop below the crude protein requirements of lactating cows at the end of July. Leaf dryness starts on 29 July and continues through August into September. The phosphorus content of lead tillers drops below the requirements of lactating cows in mid August. Lead tillers contribute little to forage value after late July.

Vegetative tillers are derived mostly from carryover tillers that were most likely fall tillers from the previous growing season and some are derived from early season initiated tillers. Vegetative tillers have slightly slower growth rates than lead tillers during the early portion of the growing season. Vegetative tillers reach the 3.5 new leaf stage shortly after the lead tillers and become independent. When lead tiller growth rates decrease greatly during mid to late June, the vegetative tiller growth rates do not slow down and may increase some. Grazing management practices that have less than 100 lbs/ac of available mineral nitrogen have less than a third of the quantity of vegetative tillers as grazing management practices that can produce greater than 100 lbs/ac available mineral nitrogen. Vegetative tillers provide around three fourths of the quality forage weight after mid July.

Secondary tillers are derived from growing season initiated tillers. With most useful tillers initiated during May and June. Few secondary tillers are initiated during the period when lead tillers have high resource demand as they progress through the flower stage and seed production. Most of the secondary tillers on traditional grazing practices are terminated during the high resource demand period resulting in only about 3% surviving secondary tillers compared to those on the twice-over system. Surviving secondary tillers become independent of the lead tillers when the fourth leaf is near full development. These secondary tillers contribute high nutrient quality to the forage weight after mid July. The quantity of vegetative and secondary tillers, and the quantity and quality of forage after mid July depends on the type of grazing management practices used during June and the first two weeks of July. Traditional grazing practices have low quantities of forage value vegetative and secondary tillers and the lactating cows much consume forage that is below their nutritional requirements after mid or late July. Fall tillers are the most common secondary tiller type on traditional management practices. Fall tillers of cool season grasses initiate from mid August to late September or later during some years. These fall tillers become the vegetative tillers during the next growing season if they are not grazed during the current growing season. Green needlegrass is a valuable asset on the Northern Mixed Grass Prairie.

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Table 1. Nassella viridula, Green needlegrass, weekly percent crude protein, percent phosphorus, and phenological growth stages of ungrazed lead tillers in western North Dakota, 1946-1947.

Sample Date	Crude Protein %	Phosphorus %	Phenological Growth Stages
Apr 1			
13	23.2	0.332	Early leaf greenup
19	26.4	0.346	
25	24.2	0.369	
May 4	23.8	0.332	Active leaf growth
10	20.2	0.368	
16	22.1	0.315	Flower stalk developing
23	18.2	0.239	
28	23.5	0.249	
Jun 6	17.9	0.262	
13	18.0	0.271	Seed developing
19	18.3	0.224	
26	14.4	0.213	
Jul 2	13.9	0.220	Seed maturing
8	12.1	0.217	
16	14.7	0.239	Seed Shedding
24	9.9	0.207	
30	10.6	0.205	Drying
Aug 6	8.3	0.184	
13	7.7	0.183	Drying
20	7.5	0.176	
26	7.5	0.173	
Sep 3	4.7	-	
12	4.8	-	Drying
21	-	-	
29	6.5	0.118	Drying
Oct			
Nov 5	4.4	0.222	Drying

Data from Whitman et al. 1951.

Table 2. Mean leaf height in cm and percent of maximum leaf height attained by Nassella viridula, Needle and thread, 1955-1962.

	April				
	1	8	15	22	29
cm		4.0	7.0	8.7	10.0
%		12.0	21.0	26.0	29.0
	May				
	1	8	15	22	29
cm	12.0	13.5	16.0	20.3	22.3
%	35.0	40.0	47.0	60.0	66.0
	June				
	1	8	15	22	29
cm	22.3	25.6	32.0	34.0	
%	66.0	75.0	94.0	100.0	
	July				
	1	8	15	22	29
cm					
%					
	August				
	1	8	15	22	29
cm					
%					

Data from Goetz 1963.

Table 3. Mean stalk height in cm and percent of maximum stalk height attained by Nassella viridula, Needle and thread, 1955-1962.

	April				
	1	8	15	22	29
cm					
%					
	May				
	1	8	15	22	29
cm					25.7
%					45.4
	June				
	1	8	15	22	29
cm	26.0	28.5	37.4	45.0	56.5
%	46.0	50.4	66.2	79.6	100.0
	July				
	1	8	15	22	29
cm					
%					
	August				
	1	8	15	22	29
cm					
%					

Data from Goetz 1963.

Table 4. First flower and flower period of Nassella viridula, Green needlegrass.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		28				
Mean			16			
Flower Period						
1969-1971			XX XX	X		

First Flower Data from Goetz 1963 and Whitman et al.
Flower Period Data from Zaczkowski 1972.

Table 5. Flower stalk seed development and percent leaf dryness of Nassella viridula, Green needlegrass.

	Flower Stalk Development			Seed Development	
Data Period	Boot	Emerge	Flower	Mature	Shed
1955-1962	26 May	12 Jun	16 Jun	2 Jul	12 Jul

		Percent Leaf Dryness			
Data Period	Leaf Tip	0-25	25-50	50-75	75-100
	Dry	%	%	%	%
1955-1962	19 Jun	29 Jul	26 Aug	11 Sep	

Data from Goetz 1963.

Table 6. Intake nutrient requirements as percent of dry matter for range cows with average milk production.

	Dry Gestation	3rd Trimester	Early Lactation	Lactation (Spring, Summer, Fall)
1000 lb cows				
Dry matter (lbs)	21	21	24	24
Crude protein (%)	6.2	7.8	10.5	9.6
Phosphorus (%)	0.11	0.15	0.20	0.18
1200 lb cows				
Dry matter (lbs)	24	24	27	27
Crude protein (%)	6.2	7.8	10.1	9.3
Phosphorus (%)	0.12	0.16	0.19	0.18
1400 lb cows				
Dry matter (lbs)	27	27	30	30
Crude protein (%)	6.2	7.9	9.8	9.0
Phosphorus (%)	0.12	0.17	0.19	0.18

Data from NRC 1996.

Table 7. Mean date of first flower and date of percentage categories of leaf senescence for Green needlegrass, 1964-1966.

Ecological Site	Anthesis	Leaf Tip Dry	Leaf 0-25% Dry	Leaf 25%-50% Dry	Leaf 50%-75% Dry
Sandy	No Data				
Silty	No Data				
Overflow	29 Jun	7 Jun	1 Jul	23 Aug	12 Sep
Thin claypan	No Data				

Data from Goetz 1970.

Table 8. Mean leaf height in cm for Green needlegrass, 1964-1966.

Ecological Site	15 Apr	30 Apr	15 May	31 May	15 Jun	30 Jun	15 Jul	31 Jul	15 Aug	31 Aug	Maximum Height
Sandy	No Data										
Silty	No Data										
Overflow	3.91	8.99	13.00	26.01	36.80	43.79	50.50	45.01	43.99	43.99	50.50
Thin claypan	No Data										

Data from Goetz 1970.

Table 9. Percent crude protein for Green needlegrass, 1964-1966.

Ecological Site		1 Jun	15 Jun	1 Jul	15 Jul	1 Aug	15 Aug	1 Sep	Mean
Sandy	No Data								
Silty	No Data								
Overflow		14.9	12.5	9.7	9.1	6.8	7.1	7.3	9.6
Thin claypan	No Data								

Data from Goetz 1975.

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