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DRY MATTER ACCUMULATION AND FORAGE QUALITY OF FOUR WARM-SEASON GRASSES IN THE NEBRASKA SANDHILLS

by

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TITLE

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I. INTRODUCTION

The Sandhill Region of north central Nebraska is the largest area of sandy soil and sand dune topography in the Great Plains. Five million hectares in size, the Sandhills supports a nearly undivided expanse of native grassland.

Native grass is a major natural resource of the Sandhills. Because of the unstable sand and strong winds, this unique area has a vegetational type unlike that of surrounding prairie. Four important and abundant grasses found in the Sandhills are little bluestem (*Schizachyrium scoparium* (Michx.) Nash.), sand bluestem (*Andropogon hallii* Hack.), sand lovegrass (*Eragrostis trichodes* (Nutt.) Wood), and switchgrass (*Panicum virgatum* L.). They are important for soil stability as well as for forage production.

Growth habits differ among grasses. Recognizing their relative differences is an important part of good range management. Because rangeland vegetation usually consists of a wide variety of plants, management is often based on the growth requirements and life histories of the principal forage producing plants. Correct use of the major forage producing species usually means correct use for the entire range. Knowledge of development, seasonal growth patterns, and forage quality of grasses is important when planning proper range use. This knowledge can help range managers plan grazing systems, understand grass responses to grazing, and follow the nutrient composition of the grass plant in relation to animal requirements. Two measures of forage quality are crude protein and *in vitro* dry matter disappearance (IVDMD).

Protein is of primary importance among the plant nutrients needed in the growth and maintenance of beef cattle. IVDMD is an estimate of the amount of dry matter per unit of consumption that is digestible by an animal.

Little bluestem, sand bluestem, sand lovegrass, and switchgrass have not been studied intensively in the Nebraska Sandhills. This study was undertaken to examine development, dry matter accumulation, and forage quality of these four grasses during two consecutive growing seasons. The study was designed to determine stages of development and growing point elevations of each grass, determine seasonal patterns in their plant, leaf blade, and stem dry matter accumulation, and analyze these plant components for crude protein and IVDMD during the 1973 and 1974 growing seasons. Information of this nature can allow more intensive management of rangeland.

II. LITERATURE REVIEW

Knowledge of development, dry matter accumulation, and forage quality of grasses can help range managers make more reliable management decisions for proper range use. Differences in development among grasses during the growing season are associated with changes in dry matter accumulation, forage quality, and response to forage removal. Development of grasses can be altered by many climatic and management factors.

Plants are closely interrelated with their environment. The term environment implies surroundings and can be broken down into a number of factors. A factor can be defined as any external force, substance, or condition that affects plants in any way. Factors can be classified into eight major categories: water, temperature, light, soil, atmosphere, physiography, fire, and the biotic factor. The growth and development of an individual plant is determined by the interaction of plant hereditary factors with factors of the environmental complex which the plant inhabits (Daubenmire, 1974).

Water is probably the single most important environmental factor influencing the growth and development of range grasses. Almost every process in grasses is affected by water. The relationship between water and the grass plant varies with plant characteristics, plant maturity and soil and climatic conditions. Precipitation of water from the atmosphere provides essentially all the soil moisture used by grasses (Chang, 1968; Daubenmire, 1974).

Of the environmental factors, temperature probably is secondary only to precipitation in its influence on grasses. Temperature also affects precipitation effectiveness as higher temperatures are associated with greater evapotranspiration losses (Humphrey, 1962).

The development of grasses has been described by several investigators (Evans and Grover, 1940; Sharman, 1947; Rechenthin, 1962; Booysen et al., 1963). Early green growth consists primarily of leaf material as the growing point (shoot apex or apical meristem) remains below the soil surface. Later in the growing season, stem internodes below the growing point elongate, elevating the growing point above the soil surface. The time and height of growing point elevation varies among grasses. At about the time of stem elongation, the growing points of fertile shoots undergo a morphological change from a vegetative to a reproductive condition. Vegetative shoots are those shoots which produce no inflorescences and fertile shoots are those complete with inflorescences. Vegetative shoots may make up 25 to 90 percent of the shoots present depending upon the grass and environmental conditions. When a shoot enters the reproductive phase, the growing point stops initiating new leaves and begins initiating the inflorescence or seed head.

The height of the growing point is a critical factor associated with the reaction of a grass plant to clipping or grazing (Cook and Stoddart, 1953; Hyder, 1972; Cable, 1974). During early vegetative growth, the leaves above the soil surface may be removed without removing the growing point and the grass plant can continue growth except for a temporary slowing down due to leaf area reduction. When internode elongation begins, the growing point may be elevated rapidly above the soil surface and become susceptible to removal. Following growing point removal, normal

shoot development is arrested and any further growth must be initiated from axillary buds at the shoot base.

Development of grasses is affected by soil moisture and temperature. Early soil moisture depletion is associated with grasses maturing early (Laycock and Price, 1970; Cable, 1971). Temperature is important in determining rate of development and phenology (Daubenmire, 1974).

Branson (1953) investigated the heights of growing points and the fertile to vegetative shoot ratios of several grasses in central Nebraska. Switchgrass growing points were elevated above the soil surface early in the growing season and by July were well above the 2.5 cm height to which cattle can graze. The fertile to vegetative shoot ratio of switchgrass was 2.15. Branson suggested that this early vulnerability of the growing points of switchgrass relative to other warm season grasses plus the high ratio of fertile to vegetative shoots contributes to the decrease of switchgrass under heavy grazing. Little bluestem growing points were elevated only slightly more than 2.5 cm above the soil surface by mid July and the ratio of fertile to vegetative shoots was 3.20. Vogel (1965) reported that elevation of little bluestem growing points above ground level began about June 15 in Missouri. Branson concluded that the high fertile to vegetative shoot ratio was a more important factor in determining the lack of resistance to grazing in little bluestem than the height of growing points. The growing points of two short grasses, blue grama (Bouteloua gracilis (H.B.K.) Lag.) and buffalo grass (Buchloe dactyloides (Nutt.) Engelm.), were at or near the soil surface throughout the growing season. The ratio of fertile to vegetative shoots was 0.15 for both grasses. The decumbent habit of growth, low leaf and shoot heights. growing points near the soil surface,

and the low ratio of fertile to vegetative shoots contributes to the high resistance of these grasses to grazing. Deterioration of rangeland is often related to too heavy stocking and preferences of livestock for individual grasses. In general, Branson found that grasses in which the growing points reached a height that permitted their removal by grazing decreased in density as utilization increased but grasses with growing points at ground level usually increased. In addition, grasses with a high ratio of fertile to vegetative shoots usually decreased under heavy grazing.

Dry matter accumulation of grasses increases as development advances (Heady, 1975; Stoddart et al., 1975). The dry matter accumulation of a plant, when plotted on a graph, is generally represented by a sigmoid curve. The sigmoid curve can be separated into three growth periods: (1) early period of slow growth, (2) middle period of rapid growth, and (3) final period of slow growth (Bonner and Galston, 1952; Salisbury and Ross, 1969). As discussed earlier, early grass growth is primarily leaf material. Stem material is added later as the shoot and inflorescence develop during the middle period of rapid growth. In the last phase, dry matter continues to accumulate, but at a slower rate.

Dry matter accumulation of grasses results from the interaction of the genetic constitution of the plant and environmental factors. Watson (1952) stated that the dry weight yield of a plant depends on: (1) initial capital, (2) relative growth rate, and (3) length of the growing season. Water supply, temperature, and light are probably the most important climatic factors (Bonner and Galston, 1952; Meyer et al., 1960). These factors regulate plant growth in many different and subtle ways, as is evident from plant responses to daily and seasonal fluctuations of

these climatic components. Other important environmental factors influencing grass growth are the soil and living organisms.

Soil moisture greatly affects dry matter accumulation of grasses. High correlations have been found between available soil moisture and grass production (Laycock and Price, 1970; Cable, 1971; Bell, 1973; Pieper and Donart, 1975). The effects of water deficiencies on grass growth include reduced size of shoot, smaller cells in the leaves which results in smaller leaf blades, reduced vigor, smaller intercellular spaces, reduced net transpiration, decreased carbon dioxide assimilation, reduced net photosynthesis, and a decrease in carbohydrate reserves (Daubenmire, 1974).

In the Great Plains, a number of studies have related herbage production to seasonal precipitation and soil moisture. Rogler and Haas (1947) found that the amount of soil moisture from the preceding fall and precipitation during the current season were important factors affecting the yield of a native mixed prairie in North Dakota. Smoliak (1956) determined that shortgrass rangeland production in Canada was highly correlated with May-June precipitation. Working with a sandhills range in eastern Colorado, Dahl (1963) found that grass yields were significantly influenced by the total precipitation of the previous two years. He also determined that the depth of moist soil on April 15 was highly correlated with grass production and that spring drought was a critical factor limiting potential grass yield. Rauzi (1964) found May-June and April through August precipitation to be highly correlated with herbage production on a shortgrass range in Wyoming. In western Kansas, Hulett and Tomanek (1969) related range forage production to seasonal precipitation with May-June precipitation giving the highest correlation.

Shiflet and Dietz (1974) determined that rangeland herbage production in southeastern Kansas was highly correlated to May through July and April through September precipitation.

Temperature has an important influence on the total yield of grasses. Even under ideal moisture conditions, extreme temperatures, either high or low, will normally result in decreased production. Temperature affects grasses by its influence on individual cell growth, respiration, sugar content, and rate of photosynthesis (Laycock and Price, 1970; Daubenmire, 1974).

In western Nebraska, Perry (1974) followed the dry matter accumulation of sand bluestem and prairie sandreed (Calamovilfa longifolia (Hook.) Scribn.) during the growing season. Between June 21 and August 9 sand bluestem dry matter accumulation per shoot increased from 0.23 g to 1.80 g and prairie sandreed increased from 0.31 g to 1.71 g. Perry stated that these two tall grasses are important for forage production in the Nebraska Sandhills.

Sims et al. (1971b) studied the growth and development of switchgrass and sideoats grama (Bouteloua curtipendula (Michx.) Torr.) in eastern Colorado during one growing season. Grass phytomers were separated into leaf blades, leaf sheaths, and stems. The lengths of these plant parts were measured and used to construct growth curves for each phytomer. Switchgrass leaf blade elongation was consistent throughout the season and most rapid just before and upon floral differentiation. Leaf sheath elongation followed the same general pattern. Extensive internode elongation commenced after floral differentiation. The growing points were elevated above the soil surface in mid June. Sideoats grama blade elongation was rapid from May 15 until after head emergence. Leaf

sheath elongation was gradual. Rapid internode elongation of sideoats grama shoots occurred between mid July and late August.

The developmental morphology of blue grama and sand bluestem was studied by Sims et al. (1973) in eastern Colorado during the growing season. Grass phytomers were separated into leaf blades, leaf sheaths, and stems with their individual lengths measured. Blue grama leaf blade elongation began in mid April and stopped by mid July. Leaf sheaths elongated linearly from early June until measurements were terminated on August 18. Internode elongation of blue grama shoots began at the time of floral initiation on June 30 and was most rapid between heading and anthesis. Sand bluestem leaf blade elongation began in April and was complete by late July. Leaf blade elongation was essentially sigmoidal while the growth rate of leaf sheaths was linear. Shoot internode elongation of sand bluestem began in late June and growing points were elevated above the soil surface by July 7.

Rice (1950) followed the growth and development of five warm-season range grasses throughout the growing season in Oklahoma. Grasses studied were little bluestem, big bluestem (Andropogon gerardi Vitman), switchgrass, Indian grass (Sorghastrum nutans (L.) Nash), and sideoats grama. All grasses initiated growth within a period of slightly over a week in early April. Early growth consisted primarily of initiation and expansion of leaves and later growth was mostly stem elongation. Some stem elongation was detected before inflorescences were initiated, but most occurred afterward. Inflorescence initiation was mostly in early June for switchgrass, June for sideoats grama, early July for little bluestem and Indian grass, and late July for big bluestem. The time between inflorescence initiation and emergence varied among the grasses, being

approximately 15 days for sideoats grama, 35 days for switchgrass, 43 days for little bluestem, 50 days for big bluestem, and 64 days for Indian grass. The time between inflorescence initiation and anthesis was slightly less than two months in little bluestem and big bluestem, slightly over two months in switchgrass and Indian grass, and about one month in sideoats grama.

Stubbendieck and Burzlaff (1971) investigated the growth pattern of blue grama in western Nebraska. A mature blue grama shoot was found to have an average of 13 complete phytomers. The first six phytomers were initiated during the previous growing season. Phytomers 7 and 8 were the first to be initiated after spring growth started during the first week in April. The leaf of the last phytomer was initiated just prior to the middle of June. In most instances the internodes did not elongate before the leaf sheath and leaf blade reached their maximum length. The major internodal elongation for all phytomers occurred over a one or two week period in late June and early July. The rate of growth of the whole plant as well as the individual phytomers followed a sigmoid pattern.

Seasonal herbage production trends in the standing crop of prairie sandreed and blue grama were investigated by Sims et al. (1971a) in eastern Colorado. Herbage accumulated steadily from the beginning of sampling in late May until mid July, when peak biomass occurred. The standing crop of prairie sandreed and blue grama then declined, with only minor fluctuations, through the following March. Uresk et al. (1975) also studied the dynamics of the standing crop for blue grama in eastern Colorado. Blue grama had an early period of rapid vegetative growth, reached a peak biomass at the bud stage to early anthesis, and then declined until spring growth began again.

Peiper et al. (1974) followed the herbage weight changes of blue grama for a complete year in New Mexico. Blue grama plants were divided into leaf blade, leaf sheath, stem, and inflorescence. Development of the individual plant parts was found to differ considerably. Leaf blades and leaf sheaths began to develop early in the growing season and stems and inflorescences developed later. Weights of leaf blades, leaf sheaths, and inflorescences began to decline in September as they dried and became detached from the stems. Stems became much more important in terms of total herbage weight during the dormant season than other blue grama parts.

The growth and development of Arizona cottontop (Trichachne californica (Benth.) Chase) was studied by Cable (1971) in Arizona. Although cottontop is a warm-season perennial grass and grows mostly during the summer, Cable found that new basal shoots normally started their development during the spring, became dormant with the cessation of spring rains, and resumed growth with the onset of summer rains at which time an inflorescence was produced. Cottontop was able to readily adapt its growth cycle to the highly variable moisture conditions of the semidesert and had the ability to initiate new shoots at any time during the spring or summer growth periods. Cable found that the early period of cottontop height growth was due largely to elongation of leaf blades and leaf sheaths. The middle period of height growth was due largely to elongation of lower internodes while most growing points were still vegetative. The final period of height growth was due to elongation of upper internodes while most growing points were becoming reproductive and inflorescences were elongating and emerging. Leaves were initiated at a faster rate than has been reported for other grasses, probably an adaptation of growing in

arid environments that enables them to complete their seasonal growth in the relatively short time when adequate moisture usually is available. Inflorescences normally began emerging from the boot 2-3 weeks after the summer growth period started. Production of new shoots, length of leaf blades, rate of internode elongation, and time of inflorescence maturation were largely controlled by the availability of soil moisture.

Many studies have established that clipping or grazing practices strongly influence forage yield. Dry matter production of individual grasses is generally reduced by close or frequent clipping or grazing (Jameson, 1963; Laycock and Price, 1970; Youngner, 1972; Heady, 1975; Stoddart et al., 1975). The more frequent and severe the forage removal, the less dry matter is produced.

Grass production is greatly affected by the time of forage removal because plants are more vulnerable at some periods than others (Stoddart et al., 1975). If defoliation occurs in the early growth stages and while moisture is available, a healthy plant can quickly replenish lost foliage and continue growth. The same level of removal is much more critical in midseason. This may be due to the increased level of physiological activity during early growth or to inadequate soil moisture to support further growth later in the season.

The forage quality of grasses depends primarily on their stage of development. It is generally known that percent crude protein and percent *in vitro* dry matter disappearance (IVDMD) decrease with advancing development (Blaser, 1964; Sullivan, 1969; Heady, 1975; Stoddart et al., 1975). In the early stages of growth, grasses are succulent and growing rapidly. Crude protein, phosphorus, and carotene percentages are usually high whereas fiber, lignin, and nitrogen-free extract percentages

are low. As the growing season advances and development progresses, grasses dry, leaf growth slows down, stems elongate, and the products of photosynthesis accumulate. As these events occur, percentages of cytoplasmic constituents such as crude protein, phosphorus, and carotene decrease and percentages of cell wall constituents such as fiber, lignin, and nitrogen-free extract increase. These changes result in progressively lower dry matter digestibility and overall lower forage quality.

Contributing to the forage quality of grasses are changes in the nutrient composition and relative proportions of each plant part. Grass leaves contain greater proportions of crude protein and digestible dry matter and less lignin and fiber than do stems (Sullivan, 1969; Heady, 1975; Stoddart et al., 1975). For this reason, the leaf to stem ratio of a grass is a fair indicator of quality. Fruits and seeds usually have a relatively high percentage of crude protein and digestible dry matter. As the grass plant matures, leaves become decreasingly important and stems increasingly important not only in relative dry weight but also in nutrient composition. As a result of these changes, the whole plant displays an almost continuous drop in percent crude protein and an increase in the fibrous constituents.

The forage quality of grasses is indirectly affected by the amount of soil moisture available (Laycock and Price, 1970). Early in the growing season soil moisture is often abundant and most grasses are green and growing rapidly. During the middle and later part of the growing season precipitation and soil moisture decrease, temperature rises, and grasses mature and dry. The change in forage quality as the growing season progresses is mostly a result of plant maturity and is only indirectly affected by the decrease in soil moisture. Early drying of soil, however,