Effects of Temperature and Daylength on Axillary Bud and Tiller Development in Blue Grama[1]

J. STUBBENDIECK[2]
AND D. F. BURZLAFF

Graduate Assistant in Agronomy and Professor of Agronomy, University of Nebraska, Lincoln.

Highlight

A study was conducted to determine the nature of tiller development and the influence of light and temperature on growth and development of the axillary buds and tillers of blue grama. An axillary bud, enclosed in a prophyllum was found at each node of the culm. The development of the axillary bud into a tiller is a function of temperature. Controlled increase of temperatures in early spring increased the rate of axillary bud and tiller development in blue grama. The data also indicate that controlled reduction in length of photoperiod decreased the growth of axillary buds and development of tillers.

Blue grama (*Bouteloua gracilis* (H.B.K.) Lag.) is abundant throughout the Great Plains of the United States and in portions of Canada and Mexico. This drought-tolerant grass is not only an important forage for grazing animals but is valuable in restoration of depleted ranges and abandoned cropland. Like most forage plants, it responds to different intensities of defoliation or grazing.

This study was undertaken to develop an understanding of the nature of tiller development in blue grama and the factors controlling it. Once these are understood it will be possible to develop controlled grazing systems.

Axillary buds on proaxes of grasses may develop new shoots, and these new shoots may again develop new shoots at their nodes. This process is called tillering (Rechenthin, 1956). It has been reported that tillering in blue grama begins simultaneously with the development of the secondary root system, and that there is an average of about one root per tiller (Weaver, 1930 and Riegel, 1941).

Growth of existing tillers in *Lolium* spp. was found to be sensitive to temperature and there was a high correlation of tiller growth with temperature for some species of *Phalaris* and *Festuca* (Cooper, 1951 and Williams and Biddiscombe, 1965). However, the optimum temperature for tillering may be lower than the optimum temperature for growth (Barnard, 1964).

It was determined by Olmsted (1943) that tiller growth in *Bouteloua* is more rapid under short photoperiods than when grown under long day photoperiods. It was concluded that cessation of elongation of individual axes during the shorter light periods resulted in continued production of basal tillers. The apical meristems remained active for longer periods during long light periods, which resulted in slower rates of basal tiller initiation.

It has been pointed out that the effect of day length on tillering is frequently confused by its effect on earliness of flowering in many grasses (Alberda, 1957). Increased tillering with decrease in day length has been found in many grasses whose flowering is hastened by long days (Gardner, 1942). Tillering may be affected by the quantity or total energy of light rather than by the photoperiod (Hamid, Blaser, and Brown, 1966).

Experimental Site and Procedures

The study site was located near the Scotts Bluff Experimental Range in southern Sioux County, Nebraska.

The average annual precipitation at the Scotts Bluff Experiment Station, seven miles south of the study area, is 12.78 inches (U.S. Department of Commerce, 1963). The precipitation at the study site was 15.46 inches for the period from February 15 to October 5, 1967. Most of the precipita-
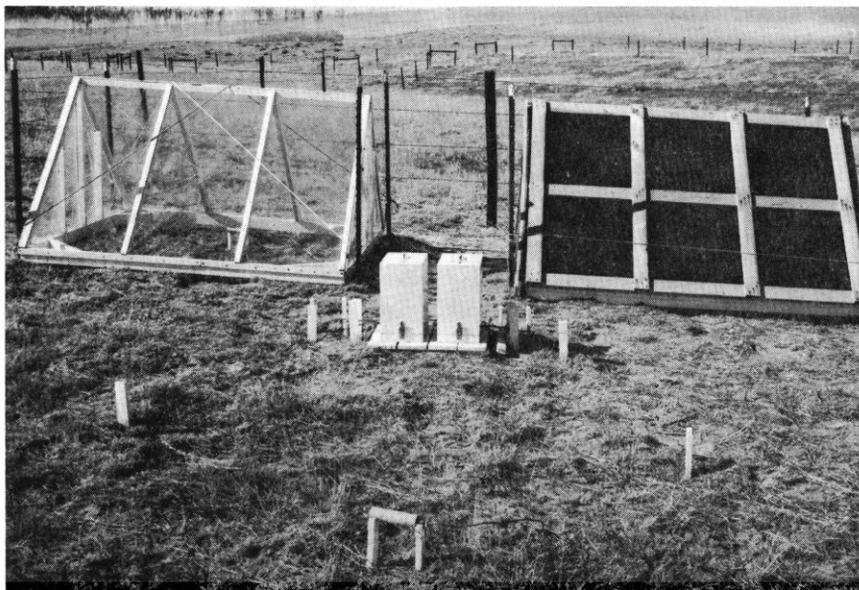
FIG. 1. Plastic greenhouses and temperature recording instruments in place on plots at the Scotts Bluff Experimental Range.

tion comes as heavy rain in the spring and summer.

The predominant soil at the study site is Valentine fine sand. The pH ranges from 7.1 in the surface few inches to 8.1 in the 18–36″ depth. The bulk density for the surface three feet is 1.44 g/cc.

Four grasses comprised the major portion of the vegetation cover and the forage produced in the area. They were blue grama, prairie sandreed (*Calamovilfa longifolia* (Hook.) Scribn.), needleandthread (*Stipa comata* Trin. and Rupr.), and sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray).

An area was selected that had a high percentage of blue grama. On March 16, 1967, portable greenhouses (Fig. 1) were placed over two of the 7 × 7 ft plots. The greenhouses were covered with .014 inch clear, polyvinyl chloride plastic.

For the purpose of limiting photoperiod, a set of frames was constructed and covered with .006 inch black, polyethylene plastic. These frames were placed around one greenhouse at 7:00 p m and removed the following morning at 8:00 a m. This process was carried out each day from March 17 to May 17, 1967. The greenhouses were removed from the plots on May 19, 1967.

The amount of precipitation was measured in a standard rain gauge. The volume of water that would fall on a 49 ft² area at each rainfall was

calculated and that amount was then applied with sprinkler can to each greenhouse plot.

Soil and atmospheric temperatures were each recorded with two, three-pen, distance thermographs. A temperature sensing unit was placed three inches below and parallel to the soil surface in each plot. A second temperature sensing unit was placed six inches above and parallel to the soil surface in each plot (Fig. 1).

Recorded temperatures were con-

verted to degree-hours. A degree-hour represents 1 C for a one-hour time duration. The degree-hours above and below 10 C (established critical temperature) were determined by measuring the total area delineated by the 10 C line on the recording chart and the temperature-recording pen with a compensating polar planimeter. Division of the area by a factor representing one degree-hour yielded the total degree-hours above or below 10 C for any 24 hour period.

Starting on March 17, 1967, plant collections were made at weekly intervals from each plot. The final collection was made on July 28, 1967.

The preserved plants were dissected in reverse order of their collection dates. This allowed the development to be more easily traced. The four plants that showed the most development for each plot and collection date were selected, and the length of the prophylla and the tillers were recorded to the nearest millimeter.

Results and Discussion

In this study, a single shoot was considered to be vegetative material separated from other plant material by the presence of a prophyllum and with at least one lateral root developed from a node immediately below the prophyllum. The prophyllum is the first leaf of the shoot (Fig. 2). It is a two-keeled structure which encloses the axillary bud (Hitchcock, 1951).
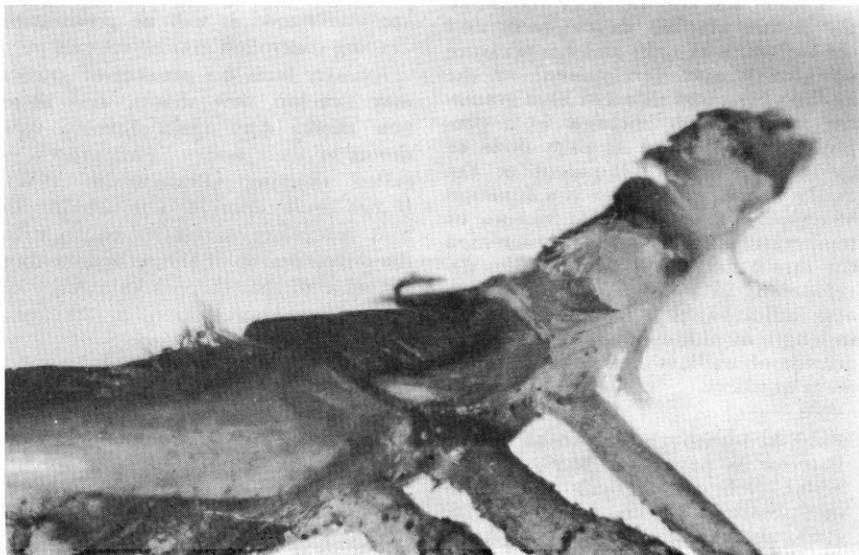
The axillary buds were tiller pri-

FIG. 2. The proaxis of a blue grama shoot showing very short basal internodes, axillary buds enclosed in prophylla, and lateral roots (10 ×).
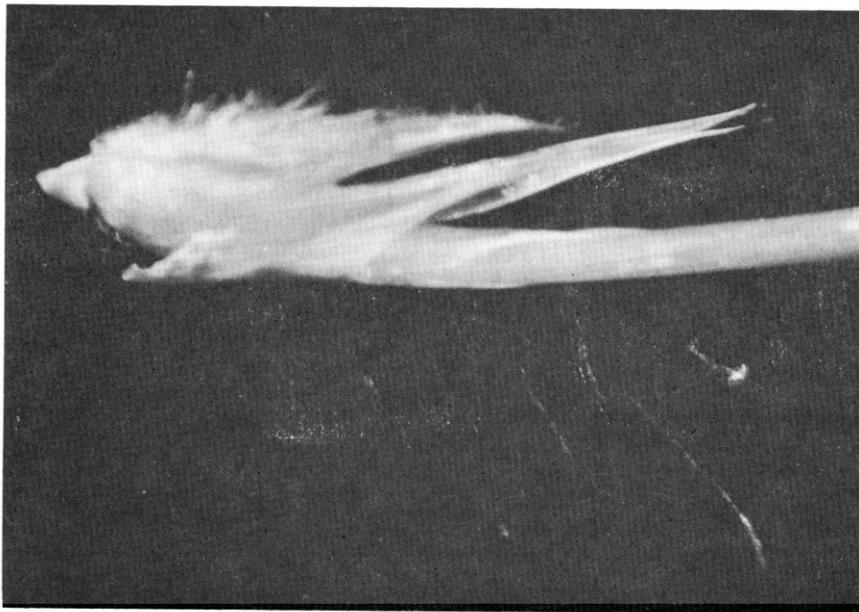
Fig. 3. A blue grama tiller showing prophyllum, scale leaf of the axillary bud, leaf sheath of phytomer 3, and the emerging sheath of phytomer 4 (5 ×).

mordia, but not all developed into tillers. In this study, an axillary bud was said to have reached developmental maturity when the new shoot emerged from the prophyllum. At this point, the axillary bud became a tiller (Fig. 3).

The results of this study indicate that light and temperature affected the time at which axillary buds of blue grama developed into tillers.

The plants in the natural-day plot had measurable elongation of axillary buds on March 31. This date was one week before measurable axillary bud growth occurred in the control plot, and three weeks before it occurred in the short-day greenhouse plot. Measurable tiller development occurred in the natural-day greenhouse plot on April 28. This date was four weeks before measurable tiller growth occurred in the control plot, and five weeks before it occurred in the short-day greenhouse plot. The variation between plants within dates and treatments can be explained by the small number (four) of shoots dissected for each treatment at each date.

Attempts to associate growth phenomena with variations in aboveground temperature accumulations were not successful. The soil temperature represented more closely the temperature of plant tissue at or just below the soil's surface. Consequently it should be expected to be somewhat

more influential on growth processes in early spring.

Soil temperatures, as measured by accumulated degree-hours (above or below 10 C), were lower for the short-day greenhouse than for either the natural-day greenhouse or the control plot. This was a result of two factors: (1) the amount of incident light was decreased by reduction of the photoperiod and (2) the extra layer of black plastic had somewhat of an insulating effect and temperatures failed to increase as rapidly in the morning as they did within the natural-day greenhouse. A basis for developing an understanding of the effects of temperature and light on axillary bud and tiller development is shown in Table 1. Certain soil-temperature phenomena occurred before the buds and tillers grew to the extent that increase in size could be observed and measured. An accumulation of at least 300 degree-

hours (above 10 C) occurred prior to the time that axillary bud development reached a measurable growth of 1 mm or more, and an accumulation of over 2,700 degree-hours (above 10 C) occurred prior to tiller development. The accumulation of degree-hours (above 10 C) was lower for the natural-day greenhouse plot than either of the other treatments at the time of measurable prophyllum and tiller development.

The quantity of light may also affect the rate of axillary bud and tiller development (Table 1). This possibility is illustrated by comparing the accumulated degree-hours at the time of measurable bud growth of the control and natural-day greenhouse plots with the short-day greenhouse plot. The plants in the short-day greenhouse plot required more than twice as many degree-hours (above 10 C) before measurable bud development occurred and approximately one-third more degree-hours (above 10 C) before tiller development could be measured, as compared to the plants from the control and natural-day plots.

The accumulated degree-hours (below 10 C) were lower in the short-day greenhouse that at the control plots (Table 1). This suggests that the delay in initiation of axillary bud development of blue grama in the short-day greenhouse, beyond that exhibited by the control plot may have resulted from reduced photoperiod rather than from temperature differential.

The accumulated degree-hours below 10 C were similar at the time of measurable axillary bud and tiller development for the short-day greenhouse and control plots. A smaller amount was recorded for the natural-day greenhouse plot.

It has been reported that the number and total length of tillers increased at, or shortly after, reproductive culm elongation ceased (Olmsted, 1943). There was an increase in the number

Table 1. Accumulated degree-hours of soil temperatures above and below 10 C (established critical temperature) at the time of measurable axillary bud and tiller growth for each treatment.

Temperature gradient	Control		Natural-day greenhouse		Short-day greenhouse	
	Axillary buds	Tillers	Axillary buds	Tillers	Axillary buds	Tillers
Above 10 C	400	2915	330	2795	910	3840
Below 10 C	2320	6595	1055	3765	2320	5610

of tillers the first week in July. This date coincides with the time at which the reproductive culm was reaching its maximum length.

Conclusion

Tillers of blue grama develop from axillary buds that are located at the node of each phytomer. The axillary bud is partially enclosed in a specialized leaf sheath (prophyllum). The development of the axillary buds and tillers was delayed when the plant was maintained under artificial short-day photoperiods.

The increase in temperature associated with the natural-day greenhouse as compared to the control resulted in tiller development four weeks earlier in the season. With the combination of lower temperatures and controlled photoperiod there was an additional one week delay of tiller development. The major increase in tiller development was associated with the mid-June

dates which coincided with the elongation of the reproductive culm.

Literature Cited

ALBERDA, T. 1957. The effects of cutting, light intensity, and night temperature on growth and soluble carbohydrate content of *Lolium perenne*. Plant and Soil. 8:199–230.

BARNARD, C. 1964. Grasses and Grasslands. McMillan & Co., Ltd. London. 269 p.

COOPER, J. P. 1951. Studies on growth and development of *Lolium*. II. Pattern of bud development of the shoot apex and its ecological significance. J. Ecol. 39:228–270.

GARDNER, J. L. 1942. Studies in tillering. Ecology 23:162–174.

HAMID, A., R. E. BLASER, AND R. H. BROWN. 1966. Tillering and carbohydrate contents of orchardgrass as influenced by environmental factors. Crop Sci. 6:139–143.

HITCHCOCK, A. S. (revised by A. Chase). 1951. Manual of the Grasses of the United States. U.S. Dep. Agr. Misc. Pub. No. 200. 1051 p.

OLMSTED, C. E. 1943. Growth and development in range grasses. III. Photoperiodic responses in the Genus *Bouteloua*. Bot. Gaz. 105: 165–181.

RECHENTHIN, C. A. 1956. Elementary morphology of grass growth and how it effects utilization. J. Range. Manage. 9:167–170.

RIEGEL, A. 1941. Life history and habits of blue grama. Trans. Kan. Acad. Sci. 44:76–83.

U.S. DEP. COMM. WEATHER BUREAU. 1963. Climatological Data, Nebraska: Yearly Summary. 68:201–213.

WEAVER, J. E. 1930. Underground plant development in its relation to grazing. Ecology. 11:543–550.

WILLIAMS, C. N. AND E. F. BIDDISCOMBE. 1965. Extension growth of grass tillers in the field. Aust. J. Agr. Res. 16:14–22.