Soil Moisture Conditions Under Pastures of Cool-Season and Warm-Season Grasses[1]

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Highlight

The season of active growth and water use by warm-season grasses is about five months, May through September, compared with seven to eight months for cool-season grasses. There was less water in the soil in midspring each year under cool-season than under warm-season grasses. Consequently, the cool-season pastures suffered from midsummer drought more often than did warm-season pastures.

Forage yields from range and pasture in the Great Plains are often reduced because of limited rainfall and low levels of soil moisture. Undesirable changes in the vegetation occur if the numbers of livestock are not reduced during drought. The soil moisture status is, therefore, an important factor in the management of pasture grasses.

Variations in the soil moisture content under two kinds of pasture, cool-season and warm-season grasses, were studied in conjunction with a grazing experiment at the Nebraska Agricultural Experiment Station at Lincoln. The results of six seasons, 1956 to 1961, inclusive, are reported here.

Experimental Area and Procedure

The soil is Sharpsburg silty clay loam. This soil was developed from Peorian loess and has a dark-colored, friable surface layer eight to 12 inches deep. Below this is a finer-textured zone grading into light brown parent material. The topography is gently rolling to nearly level.

The average annual precipitation at the Agronomy Farm for the 25-year period, 1931-1955, was 26.79 inches. The amount of moisture that falls during the autumn and early winter may have an important effect on forage yield the following season. Therefore, precipitation amounts are shown by crop-years (October 1 through September 30) for the six-year period, October 1955 through September 1961 (Figure 1).

Six warm-season pastures were planted in early May, 1954. These included one pasture each of big bluestem (*Andropogon gerardi* Vitman), side-oats grama (*Bouteloua curtipendula* (Michx.) Torr.), and Nebraska 28 switchgrass (*Panicum virgatum* L.) in pure stands, and one pasture of each of these grasses in mixture with Nebraska 27 sand lovegrass (*Eragrostis trichodes* (Nutt.) Wood). Two pastures of each of three cool-season grasses, Lincoln bromegrass (*Bromus inermis* Leyss.), tall wheatgrass (*Agropyron elongatum* (Host) Beauv), and intermediate wheatgrass (*A. intermedium* (Host) Beauv), were planted in early September of the same season. All pastures were five acres in size.

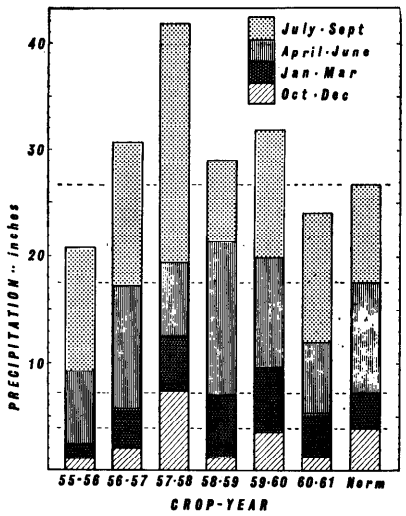

FIGURE 1. Quarterly and annual precipitation at Agronomy Farm, Lincoln, Nebraska, for crop-years (October 1 through September 30) 1955-56 to 1960-61, inclusive; and for the 25 years, 1931-55 (Norm). Quarterly norms indicated by dotted lines. Data from the Weather Bureau, U. S. Department of Commerce.

The warm-season grasses were cut for hay in August, 1955. The cool-season grasses were harvested for seed. All the pastures were grazed with yearling Hereford steers each season beginning in the spring of 1956.

Samples for soil moisture determinations were taken in 12-inch increments to a depth of five feet with a Veihmeyer-King soil tube. The moisture content of each sample was determined gravimetrically. Moisture determinations were made several times each season. Usually, soil cores were taken from two to four representative areas in each of eight or more pastures at each time of sampling. In every case, the same number of samples were taken from cool-season and warm-season pastures. The dates of sampling are shown in the tables with the results.

The water-holding capacity of the soil at 15 bars tension was determined with the pressure-membrane apparatus (Richards, 1947) for samples from several locations in the area.[2] The moisture content at this tension is considered to be approximately the permanent wilting percentage for many soils. In this study, moisture contents below the 15-bar percentage were found on several occasions, even at depths below two feet. Therefore, 85% of the 15-bar percentage is considered to be the permanent wilting point for the grasses used, and any water in excess of this amount is reported as the "available water" at each date of sampling.

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[2]*The authors gratefully acknowledge the valuable assistance given by Dr. A. P. Mazurak, Professor of Agronomy, University of Nebraska, in determining and interpreting the 15-bar moisture percentages of the soil.*

Results

When the pastures were fenced in early December 1955, the soil under the cool-season grasses was dry and hard to a depth of 30 inches or more, but that under the warm-season grasses was relatively moist. More than four inches of rain had fallen during the last half of September plus 0.65 inch in October and November. Apparently, the rain which fell after mid-September was used almost immediately by the cool-season grasses for fall growth, while much of that which fell on the warm-season grasses was stored in the soil as reserve moisture.

Precipitation from October 1, 1955, through March 1956, was 2.40 inches, or 4.82 inches less than the long-term average for the six-month period (Figure 1). When the soil was sampled in late March 1956, there was only 0.81 of an inch of available water in the upper five feet of soil under the cool-season grasses as compared with 2.75 inches under the warm-season pastures (Table 1). Thus, at the beginning of the growing season, the available moisture reserve under the warm-season pastures was 1.94 inches more than that under the cool-season. This was reflected in the production from the two kinds of pasture in 1956.

Large patches of the cool-season grasses wilted severely in late April 1956, but they recovered rapidly during a week of light showers, April 28 to May 4. Rainfall amounts continued below the long-term average each month through July. As a result, the cool-season pastures averaged only 54 steer-days of grazing and 57 pounds of gain per acre in a 90-day grazing season, May 21 to August 19 (Table 2). The warm-season pastures, with a reserve of about three inches of available water in the soil at the beginning of their growing season (May 1), produced 121 steer-days of grazing and 140 pounds of gain per acre in a 106-day season, June 18 to October 12.

The available moisture was nearly exhausted under both kinds of pasture in late July 1956, but on October 10, there was 0.98 inch of available water in the upper three feet of soil under the warm-season grasses as compared with none under the cool-season pastures (Table 1). Apparently this difference in amount of soil moisture in the fall was due to the differences in amount of fall growth and corresponding rates of water use by the two kinds of grass.

In mid-April of 1957, the upper two feet of soil under the cool-season grasses contained 3.07 inches of available water, but below this layer, the soil was dry to a depth of five feet (Table 3). In contrast, the soil under the warm-season grasses contained 3.82 inches of available water in the upper two feet plus 1.60 inches in the two-to-five-foot zone, a total of 5.42 inches.

Rainfall in 1957 was near normal in each of the three months, June, July, and August. Both kinds of grasses grew vigorously during the 8 weeks, May 20 to July 16. Although 12.57 inches of rain fell during this period, the cool-season grasses reduced the amount of available water in the soil by 1.95 inches, from 2.94 to 0.99 inches. The warm-season grasses reduced the available moisture reserve 1.75 inches, from 6.76 to 5.01 inches, during the same period. In the next five weeks, the available soil moisture decreased 0.21 of an inch under the warm-season pastures, while it increased 1.36 inches under the cool-season.

Table 1. Available water[1] in the soil at different depths to five feet under cool-season and warm-season grass pastures in 1956 at Lincoln, Nebraska.

Date sampled and kind of grass	Inches of available water in the soil at depths, in inches, of					
	0-12	12-24	24-36	36-48	48-60	Total
March 22						
Cool-season	0.54	0.05	0.01	0.10	0.11	0.81
Warm-season	1.50	0.55	0.08	0.16	0.46	2.75
July 19						
Cool-season	0.47	0.00	-0.16	-0.10	0.06	0.53
Warm-season	0.23	-0.05	0.01	0.13	0.37	0.74
September 11						
Cool-season	1.10	0.28	-0.03	0.00	0.11	1.49
Warm-season	1.44	0.45	0.01	0.10	0.29	2.29
October 10						
Cool-season	-0.33	-0.08	-0.08	——[2]	——	0.00
Warm-season	0.17	0.48	0.33	——	——	0.98

[1] Water in excess of 85% of the amount held by the soil at 15 bars tension is considered to be available to the grasses.

[2] Soil sampled only to a depth of 3 feet on October 10.

Table 2. Production, in terms of animal performance, from cool-season and warm-season pastures at Lincoln, Nebraska, in 1956 and 1957.[1]

Year	Kind of pasture	Length of grazing season			Steer-days of grazing per acre	Gains in body wt. per acre
		From	To	Days		
				No.	No.	Pounds
1956	Cool-season	May 21	Aug. 19	90	54	57
	Warm-season	Jun. 18	Oct. 2	106	121	140
1957	Cool-season	May 13	Oct. 9	149	135	134
	Warm-season	Jun. 19	Oct. 9	112	137	133

[1] Average initial weights of the yearling Hereford steers were 650 pounds in 1956 and 590 pounds in 1957.

Table 3. Available water[1] in the soil at different depths to five feet under cool-season and warm-season grass pastures in 1957, at Lincoln.

Date sampled and kind of grass	Inches of available water in the soil at depths, in inches, of					
	0-12	12-24	24-36	36-48	48-60	Total
April 16						
Cool-season	1.77	1.30	-0.04	-0.06	0.05	3.12
Warm-season	2.13	1.54	0.99	0.33	0.35	5.34
May 20						
Cool-season	1.78	0.97	0.13	-0.10	0.06	2.94
Warm-season	2.32	1.75	1.40	0.75	0.54	6.76
June 25						
Cool-season	1.16	0.72	0.01	0.00	0.03	1.92
Warm-season	1.81	1.50	1.35	0.95	0.63	6.24
July 16						
Cool-season	0.16	0.42	0.16	0.11	0.14	0.99
Warm-season	0.49	1.05	1.11	1.14	1.22	5.01
August 20						
Cool-season	1.25	0.58	0.20	0.16	0.16	2.35
Warm-season	1.75	0.57	0.49	0.98	1.01	4.80
September 28						
Cool-season	0.88	0.84	0.56	0.33	0.33	2.94
Warm-season	1.66	1.05	0.76	0.98	1.11	5.56

[1]Water in excess of 85% of the amount held by the soil at 15 bars tension is considered to be available to the grasses.

The cool-season grasses were nearly dormant and made little or no new growth during this period.

The two kinds of pasture were about equal in production in 1957. The cool-season pastures were grazed through a longer season than the warm-season pastures; May 13 to October 9 (149 days) and June 19 to October 9 (112 days), respectively. The steers on cool-season pasture lost an average of 27 pounds per head during August while those on warm-season pasture gained 14 pounds per head during the month. Number of steer-days of grazing and pounds of gain per acre were nearly equal for the two kinds of pasture (Table 2).

Precipitation during the six months, October 1957 through March 1958, was 12.60 inches. This is 75% above the long-time average for the period. On April 19, the average amounts of available water in the upper five feet of soil under cool-season and warm-season grasses were 7.63 and 9.65 inches, respectively (Table 4).

Precipitation in April, May, and June was 33% less than normal, yet there was no evidence that growth of any of the grasses was limited because of insufficient water. Apparently, the large reserves of water in the soil at the beginning of the season were sufficient to meet the needs of the grasses until heavy rains occurred in July.

Variations in the amounts of water in the upper five feet of soil under the two kinds of grass during a representative two-year period, August 1959 through July 1961, are shown graphically in Figure 2. Total precipitation during the period was 2% less than the long-time average. At the beginning of the period, the amounts of available water in the five-foot profile under the cool-season and warm-season grasses were nearly equal, 3.18 and 3.74 inches, respectively. In 1960, the new herbage growth of the cool-season grasses began in mid-March; that of the warm-season grasses the last of April. Both kinds of grass used water rapidly during late spring and early summer. Rainfall between May 14 and July 16 totaled 8.77 inches; yet the amount of available water in the soil decreased to 2.52 inches under cool-season and to 6.26 inches under warm-season pastures. Available moisture supplies under the cool-season grasses remained relatively constant during late summer and early fall, totaling 3.43

Table 4. Available water[1] in the soil at different depths to five feet under cool-season and warm-season grass pastures in 1958, at Lincoln.

Date sampled and kind of grass	Inches of available water in the soil at depths, in inches, of					
	0-12	12-24	24-36	36-48	48-60	Total
April 19						
Cool-season	1.77	1.61	1.48	1.47	1.30	7.63
Warm-season	2.31	1.75	1.69	1.84	2.06	9.65
June 2						
Cool-season	1.16	0.92	0.92	1.11	0.92	5.03
Warm-season	1.93	1.44	1.43	1.58	1.74	8.12
July 8						
Cool-season	1.19	0.68	0.57	0.88	1.00	4.32
Warm-season	1.33	0.62	1.07	1.32	1.57	5.91
July 18						
Cool-season	2.04	1.30	0.85	0.83	0.78	5.80
Warm-season	2.41	1.70	1.45	1.44	1.74	8.74
August 15						
Cool-season	1.39	1.14	0.80	0.70	0.43	4.46
Warm-season	1.66	1.21	1.11	1.21	1.52	6.71
October 31						
Cool-season	0.48	0.78	0.83	1.06	1.05	4.20
Warm-season	1.33	1.27	1.17	1.36	1.63	6.76

[1]Water in excess of 85% of the amount held by the soil at 15 bars tension is considered to be available to the grasses.

inches on August 23, and 3.48 inches on November 15. Under the warm-season grasses, the amount of available water decreased to 5.58 inches on August 23 and then increased to 8.15 inches in mid-November.

The pattern of soil moisture supplies during the spring and summer of 1961 was similar to that in 1960. On April 20, the amounts of available water in the upper five feet of soil under cool-season and warm-season grasses were 5.85 and 10.38 inches, respectively. These decreased to 2.01 and 5.41 inches, respectively, on July 1 and to 0.96 and 4.03 inches on August 1. Rainfall during the four months, April through July, was only 9.34 inches, 28% less than normal for the period. Production of the cool-season pastures was sharply curtailed after late June by drought. But the large reserves of available soil moisture under the warm-season pastures in early May were sufficient to maintain high production throughout the summer.

In 1961, the cool-season pastures were stocked to obtain maximum allowable use of the forage during the spring and early summer while the forage quality was high. Then the steers were moved to warm-season pastures for the remainder of the summer and back to the cool-season pastures for a month in the fall. Under this system of management, yearling steers gained 254 pounds per head during a 164-day grazing season. The cool-season pastures produced 143 days of grazing and 267 pounds of gain per acre. This is 12% fewer days of grazing but 54% more gain per acre than were obtained from these pastures in 1958 and 1959, when they were stocked for season-long grazing.

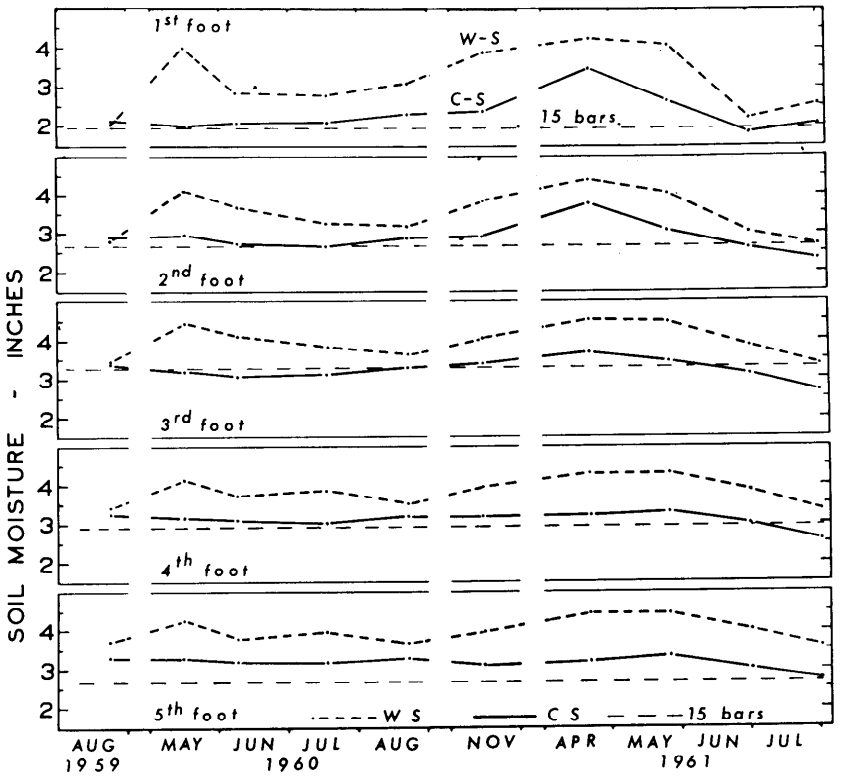

FIGURE 2. Amounts of water in upper five feet of soil under cool-season (C-S) and warm-season (W-S) grass pastures during the period from mid-August 1959 through July 1961, compared with average water-holding capacity of the soil at 15 bars tension. Agronomy Farm, Lincoln, Nebraska.

Discussion and Conclusions

Most of the important native forage plants in the Central Great Plains are warm-season grasses. These grasses do not begin their growth in the spring until the weather and soil have become warm, usually the last of April or first of May in Nebraska. They grow rapidly during the warm weather of late spring and summer if moisture is available. With the coming of shorter days and cool nights in early fall, these grasses become semi-dormant. They stop growing with the first killing frost. Hence, under a stand of warm-season grasses, most of the moisture that enters the soil during the fall, winter, and early spring may be stored for use during their growing season, midspring through the summer.

The cool-season grasses renew growth as soon as the soil thaws in the spring, usually late March in Nebraska. These grasses tend to become dormant, or at least make little growth, during the hot weather of midsummer. They renew growth again in late summer or early fall if water is available. Cool-season grasses are frost tolerant and will continue to grow until the soil freezes in late fall or early winter. Generally, much of the moisture that comes during the fall and early spring is used immediately. Therefore, soil moisture reserves do not accumulate under stands of cool-season grasses during the fall, winter, and/or early spring except in seasons of above normal precipitation.

Precipitation in the Central Great Plains varies greatly from year to year and within years. Normally, rainfall from October through March is low. Drought periods occur frequently. Insufficient moisture in the soil often is the principal factor limiting range and pasture production. The results obtained in this study indicate that cool-season and warm-season grasses should be planted in separate pastures.

The cool-season pastures will use late summer and fall moisture to produce forage for fall grazing. The winter and early spring moisture will be used in the production of early growth for spring grazing. At the same time, the fall, winter and early spring precipitation may be stored in the soil under the warm-season pastures to insure maximum production of forage for summer grazing.

In the Flint Hill Region, where most of the desirable forage species are warm-season grasses, the greatest production of beef cattle was obtained when grazing was deferred until mid-June each year (Anderson, 1940). Such deferment is not practical unless the stockman has some cool-season pasture for the stock during the spring. If the two kinds of grasses are grown in mixture in the same pasture and the grazing animals have free choice of plants to eat, it is impossible to obtain full use of each grass in its proper season. Where the two kinds of grasses are grown in separate pastures, each can be grazed in its proper season and a relatively uniform carrying capacity can be maintained throughout a long grazing season each year.

Summary

Amounts of water in the soil to a depth of five feet under cool-season and warm-season grass pastures were determined several times each year, 1956 to 1961, inclusive. The results are reported in terms of inches of "available water." Soil moisture in excess of 85% of the amount held by the soil at 15 bars tension was considered to be available to the grasses used in this study.

Six warm-season pastures in the study included one each of big bluestem, side-oats grama, and switchgrass in pure stands and one pasture of each of these grasses in mixture with sand lovegrass. Six cool-season pastures included two each of smooth bromegrass, intermediate wheatgrass, and tall wheatgrass.

There was less water in the soil under the cool-season than under the warm-season grasses in midspring each year. The amounts under the warm-season grasses ranged from 25% to 240% more than under the cool-season grasses. Consequently, the cool-season pastures suffered from midsummer drought more often than did the warm-season pastures.

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