Response of Shortgrass Plains Vegetation to Clipping, Precipitation, and Soil Water

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Highlight: *Clipping shortgrass range in Texas at 2-week intervals gave 94% more forage yield than fall harvest. Clipping treatments had little effect on ground cover and plant composition. Yield was shown to be a function of current season precipitation, while plant composition and ground cover were more closely related to previous season precipitation. In the one of seven seasons when stored soil water was available at the beginning of the growing season (4.91 inches of plant-available water), it was depleted by June 15.*

On cropped lands, relationships among precipitation, soil water, and yields have been determined, and probabilities for given levels of production have been calculated (Cole and Matthews, 1940; Burnett and Moldenhauer, 1957; Army et al., 1959; Bond et al., 1962). On range and pasture lands, however, little attention has been given to the effects of precipitation and soil water on plant growth. Rogler and Haas (1947), working with native mixed prairie in North Dakota, found that the important variables affecting yield were amount of soil water the preceding fall and amount of precipitation during the current season. Dahl (1963), working on a sandhill range type in Colorado, found that depth of moist soil and amount of soil water on April 15 were usable indices for predicting forage production through early August.

Klipple and Costello (1960) conducted one of the more comprehensive studies determining permissible use of shortgrass range. They concluded that removal of 50% by weight of the current growth of blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*) by early November was the maximum grazing that would allow shortgrass ranges to be maintained in satisfactory condition.

In 1966, a study was initiated to obtain information on climate-soil-plant relationships on a clay upland shortgrass range site. Specific objectives were: (1) to determine precipitation-soil moisture-shortgrass growth relationships under four clipping regimes, and (2) to determine effect of height and frequency of clipping of shortgrass range on: (a) forage production, (b) mineral concentration in forage, (c) botanical composition and ground cover, and (d) soil water utilization. This paper reports some of the results and relationships obtained during the first 8 years of the study.

Experimental Site and Procedure

The study was conducted on the Southwestern Great Plains Research Center, U.S. Department of Agriculture, Bushland, Texas. Average annual precipitation is 18.33 inches, approximately 75% of which falls between April 1 and September 30. The soil is Pullman clay loam with a 1% slope. More complete descriptions of the climate and soil are available (Taylor et al., 1963).

The experiment was established in native rangeland. Treatments were: (1) clipped to 2 inches each 2 weeks; (2) clipped to 1 inch each 2 weeks; (3) clipped to 1 inch at mid-season and end of season; and (4) clipped to 1 inch at end of season only. Clipping of treatments 1 and 2 began in early June and continued throughout the growing season. Clipping was deferred during drought periods when no forage was produced. Treatments were arranged in a randomized block design and replicated three times. Individual plots 40 by 100 feet, were placed with long sides at right angles to the slope contours. Each plot was split lengthwise into two equal subplots. Treatments (heights and frequencies of clipping) were identical on both subplots. Yield, botanical composition, and runoff were measured on one subplot, and soil moisture was measured on the adjacent subplot. This arrangement permitted the estimation of various parameters without having one biased by another. Plot borders consisted of concrete curbs which were run in place and extended approximately 24 inches below the soil surface. Downslope ends were left open to allow runoff. On plots where runoff was measured, the open ends were closed and flumes and water stage recorders were installed.

We measured forage yields, precipitation, soil moisture, runoff, ground cover, and botanical composition. Forage was harvested with a rotary lawnmower with a bag attachment. Entire subplots were

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Table 1. Dry matter yields (lb/acre, oven dry) of native shortgrass rangeland by heights (inches) and frequency of clipping, 1967-1970 and 1972.

Clipping		Years					
Height	Frequency	1967	1968	1969	1970	1972	Average
2	2 weeks*	255d**	335c	446c	464a	1,574b	614d
1	2 weeks*	1,539a	1,360a	1,378a	485a	2,108a	1,374a
1	July & Oct.	1,369b	1,239a	1,276a	372b	1,276c	1,107b
1	Oct.	565c	855b	923b	266c	933d	708c

* Clippings were not made during drought periods when no forage was produced. Two-week frequency treatments were clipped 4, 3, 6, 2, and 4 times in 1967, 1968, 1969, 1970, and 1972, respectively.

**Means in the same column followed by the same letter are not significantly different at 5% level.

Table 2. Dry matter yields (lb/acre, oven dry) of native shortgrass rangeland by dates, heights, and frequency of clipping, 1973.

Clipping		Date of harvests								Total		
		5-23										
Height (inch)	Frequency	Total dry matter	Native grasses	Annual grasses	Broadleaf weeds	6-14	7-26	9-12	12-14	Dry matter	Native grass	Weeds
2	2 weeks	646	216	282	148	249	–	149	185	1,229b[1]	799	430
1	2 weeks	1,608	703	220	685	342	–	353	124	2,427a	1,522	905
1	July & Oct.	–	–	–	–	–	878	–	544	1,422b	–	–
1	Oct.	–	–	–	–	–	–	–	1,206	1,206b	–	–

[1] Means followed by the same letter are not significantly different at 5% level.

harvested, forage was weighed, and subsamples were oven dried and ground through a Wiley mill. Subsamples collected in 1972 were analyzed for total nitrogen, phosphorus, potassium, and magnesium. Nitrogen was determined by the Kjeldahl method, phosphorus by the method of Kamphake et al., (1967), and potassium and magnesium by atomic absorption spectrophotometry.

Gravimetric soil moisture measurements were made at the beginning of the growing season, after each rain of 0.50 inch or more, and after each harvest. Soil samples were taken in 6-inch increments to 2 or more feet. Depth of sampling depended on moisture penetration. One sample was taken at the upper end and another at the lower end of each plot.

Six plots receiving two treatments, clipped to 1 inch every 2 weeks and clipped to 1 inch in October, were instrumented for runoff measurements. Runoff was measured with FW-1 water stage recorders through 0.8-ft-deep HS flumes (U.S. Dep. Agr., 1962). Precipitation was measured with a standard U.S. Weather Bureau rain gage.

Ground cover and botanical composition were measured each fall by reading ten permanently established line transects across each plot. Initial ground cover and botanical composition data were collected in the fall of 1966, and clipping treatments were begun in 1967. Moisture conditions limited clippings on 2-week frequency treatments to 4, 3, 6, 2, 4, and 4 in 1967, 1968, 1969, 1970, 1972, and 1973, respectively. Plots were not clipped in 1971 because of a drought which began in mid-1970 and extended through much of the 1971 growing season. Precipitation from July 1, 1970, through June 30, 1971, totaled only 7.57 inches. Only three events of more than 0.50 inch occurred during that period (0.72 inch on August 21, 0.90 inch on October 16, and 1.53 inches on June 19). Clipping was deferred to prevent loss of stand.

Results and Discussion

Conditions during the first 7 years of the study (through 1972) were typical, in that there was little winter rainfall, the soil was seldom wetted below 12 inches and never wetted below 18 inches, and weed growth was sparse. However, in 1973, pre-season rainfall was much above average, the soil was wetted to 4 feet at the beginning of the growing season, and early-season weed growth was abundant. Also, ground cover and botanical composition data were not collected in 1973. Although 1973 was atypical and data for that year are incomplete, 1973 results are important because they show the effects of stored soil water. Therefore, 1973 data are presented separately.

Yield data for 1967 through 1972 are given in Table 1. Clipping to 1 inch at 2-week intervals gave highest yields in all years. This treatment gave significantly higher yields than any other treatment for the 5-year period and in 2 of the 5 individual years. Clipping at 1 inch twice per season, in July and October, gave yields approaching those on the highest yielding treatment. The other two treatments gave much lower yields. Clipping annually in October simulated winter grazing of forage (Klipple and Costello, 1960). Compared with clipping at 2-week intervals, harvest at the end of the season gave about 48% less dry matter yields. Clipping has been shown to increase forage yields of some species (Drawe et al., 1972) but yields of blue grama have been decreased by clipping (Dodd and Hopkins, 1958; Reed and Dwyer, 1971). In this case, the lower yield from the single October harvest appeared to be more a result of decomposition and disappearance of forage produced earlier in the season than of increased growth with clipping or decreased growth with delayed harvest. When growth ceases because of drought, the forage desiccates and decomposes. For example, in 1967, since precipitation distribution caused major growth to occur early in the season, the single October harvest yielded only 37% as much as the 2-week clipping schedule; whereas in 1969, when growth occurred throughout the season, October harvest yielded 67% as much as the 2-week clipping schedule.

In 1973, early-season weight loss with delayed harvest was more severe than that in other seasons (Table 2). However, weeds constituted 56% of the dry matter produced at the first harvest. The principal broadleaf weed was peppergrass (*Lepidium densiflorum*), and the principal annual grass was little barley (*Hordeum pusillum*). Yields of the three components are given in Table 2. Cool season annual weeds began growth early and used much soil water before the native grasses started growing. Weeds matured early, and plots first harvested in July yielded only 45% as much dry matter as those harvested earlier. Part of the lost material was unpalatable broadleaf weeds; however, little barley is palatable when it is immature and at least some of the native grass forage was lost, since plants were dormant from June 14 to harvest on July 26.

Mineral composition data also emphasize the desirability of using the forage during the growing season. Percent composition and yield of nitrogen, phosphorus, potassium, and magnesium data for 1972 are given in Table 3. Mineral constituent levels in young unweathered forage remain relatively constant during the growing season, but decline in aging and weathered tissue. Although levels of these constituents normally decline with plant maturity, much of the loss seemingly results from leaching of the constituents from dried tissue. Rainfall after drought periods results in new

Table 3. Percent nitrogen, phosphorus, potassium, and magnesium in forage at harvest dates, 1972.

Clipping Height (inch)	Clipping Frequency	Harvest date 6-7	7-19	8-24	9-19	10-24	Yield of constituent (lb/acre)
Nitrogen							
2	2 weeks	1.65	1.83	1.68	1.64	–	26.6
1	2 weeks	1.87	1.86	1.84	1.80	–	39.0
1	July & Oct.	–	1.64	–	–	0.99	18.7
1	Oct.	–	–	–	–	1.07	10.0
Phosphorus							
2	2 weeks	.189	.208	.192	.175	–	3.01
1	2 weeks	.173	.203	.186	.180	–	3.87
1	July & Oct.	–	.171	–	–	.111	1.98
1	Oct.	–	–	–	–	.133	1.34
Potassium							
2	2 weeks	1.04	0.94	0.94	1.00	–	15.8
1	2 weeks	1.10	1.12	0.98	1.08	–	22.4
1	July & Oct.	–	0.85	–	–	0.45	9.5
1	Oct.	–	–	–	–	0.51	4.7
Magnesium							
2	2 weeks	0.21	0.14	0.12	0.15	–	2.75
1	2 weeks	0.20	0.16	0.12	0.16	–	3.67
1	July & Oct.	–	0.12	–	–	0.07	1.34
1	Oct.	–	–	–	–	0.07	0.62

growth of existing phytomers, but the dried material is lost. Compared to clipping to 1 inch at 2-week intervals, clipping to 1 inch in October resulted in loss of 74% of the nitrogen, 68% of the phosphorus, 79% of the potassium, and 83% of the magnesium accumulated in the forage (calculated from loss of dry matter and decline in percentage composition).

Clipping to 1 inch every 2 weeks did not reduce ground cover (Table 4) or percentage blue grama in the stand (Table 5). In 1967 and 1970, clipping to a 2-inch height resulted in significantly greater percentage ground cover than clipping to 1 inch. Frequency of clipping apparently had little additional effect on ground cover.

In all years except 1971, blue grama and buffalograss accounted for 95% of the vegetation. In 1971, forbs, weeds, and grasses other than blue grama or buffalograss made up from 4 to 22% of the vegetation. Blue grama composition of the plant cover was not affected by the clipping treatments (Table 5). Compared to 1-inch clipping, the lighter utilization under 2-inch clipping had little effect on plant vigor as measured by ground cover (increased 2 years) and botanical composition (no effect). However, yields on the 2-inch clipping treatment were more competitive with those on the 1-inch treatment in 1970 and 1972 than they were in the preceding seasons. This may be a manifestation of the often-noted situation where relatively heavy use shows a production advantage for several years, after which the stand responds to moderate treatment.

Water Plant-Growth Relationships

Annual and growing season precipitation and runoff (April through September) for the 8 years are presented in Table 6. Since runoff differed little between the two instrumented treatments, averages of treatments are presented. Growing season precipitation ranged from 7.2 inches to 16.1 inches, and averaged 12.1 inches. Runoff ranged from zero to 1.25 inches per year.

Stored soil water was sufficient in only one season (1973) to permit a study of soil water-plant growth relationships. On May 4, 1973, the soil was wetted to a depth of 4 ft on all plots. The soil contained about 4.91 inches of plant-available water. By May 25, 1.95 inches of that water had been used and by June 15, the remaining 2.96 inches had been removed. Soil was equally dry under all clipping treatments. At later sampling dates (July 26, August 15, and December 14), the soil contained no appreciable plant-available water. (Plant-available water was water in the soil on May 4 less that remaining on June 15 when plants were dormant.) Precipitation was 1.18 inches from May 4 to May 25 and 0.96 inch from May 25 to June 15. By June 15, 7.05 inches of water (4.91 inches of soil water + 2.14 inches precipitation) had been used in producing 1,950 lb dry matter, giving an average water-use efficiency of 277 lb dry matter per acre-inch of water. For the period between harvests (May 23-June 14) when 342 lb dry matter was produced, water-use efficiency was 37 lb per acre-inch.

Although these data are from only one year, they illustrate the course of events when stored soil water is appreciable early in the season. Cool season annual weeds use much soil water before native grasses start growth. Early weed control might conserve stored soil water; however, our data show that water use between May 25 and June 15 was the same on all plots even though some treatments were clipped on May 25. Although

Table 4. Percent ground cover on native shortgrass rangeland by heights and frequency of clipping, 1966-1972.

Clipping Height (inch)	Clipping Frequency	Years 1966[1]	1967	1968	1969	1970	1971[2]	1972	Average
2	2 weeks[3]	18.0	30.0a[4]	26.8a	24.8a	43.4a	24.5a	39.9a	29.6a
1	2 weeks[3]	10.0	24.1b	28.3a	23.2a	37.7bc	22.9a	37.0a	26.2a
1	July & Oct.	19.2	25.3b	26.7a	24.7a	38.9ab	21.6a	35.1a	27.0a
1	Oct.	19.3	26.1b	26.9a	24.7a	34.4c	26.6c	35.2a	27.6a
Avg.		16.6	26.4	27.2	23.8	38.6	23.9	36.8	27.6

[1] All plots treated alike in 1966. Clipped only after ground cover data taken in October.
[2] No clippings made in 1971.
[3] Clippings were not made during drought periods when no forage was produced. Two week frequency treatments were clipped 4, 3, 6, 2, and 4 times in 1967, 1968, 1969, 1970, and 1972, respectively.
[4] Means in the same column followed by the same letter are not significantly different at the 5% level.

Table 5. Percent composition of blue grama on native shortgrass rangeland by heights and frequency of clipping, 1966-1972.

Clipping		Years							
Height (inch)	Frequency	1966[1]	1967	1968	1969	1970	1971[2]	1972	Avg
2	2 weeks[3]	80.6	63.4	78.7	74.3	77.8	64.7	70.1	72.8
1	2 weeks[3]	66.9	59.9	67.0	66.4	66.2	47.5	52.1	60.9
1	July & Oct.	71.3	60.7	71.2	68.0	67.9	58.1	63.1	65.8
1	Oct.	76.8	75.7	78.5	79.5	77.4	56.4	66.8	73.0
Avg.		73.9	64.9	73.9	72.0	72.3	56.7	63.0	68.1

[1] All plots treated alike in 1966. Clipped only after composition data taken in October.
[2] No clippings made in 1971.
[3] Clippings were not made during drought periods when no forage was produced. Two-week frequency treatments were clipped 4, 3, 6, 2, and 4 times in 1967, 1968, 1969, 1970, and 1972, respectively.

Table 6. Precipitation (inches) and runoff (inches) during the experimental period.

	Precipitation		
Year	Annual	April-Sept.	Runoff
1966	10.16	9.23	0
1967	14.85	12.68	0.54
1968	19.51	13.25	0.87
1969	24.75	16.08	0.40
1970	9.46	7.24	0
1971	19.55	13.15	1.25
1972	20.50	14.58	0
1973	16.13	10.19	0

weed control might not conserve water for use later in the season, control of unpalatable broadleaf weeds would leave more water available for production of more palatable forage.

In all other years, early season soil water storage was insufficient for studies of soil water-plant growth relationships. Usually, the soil did not contain enough water for a measurable contribution to grass growth. When the soil contained a small amount of water, it was stored in the surface few inches, thus was highly susceptible to evaporation.

Relationships between current and previous growing season precipitation and yield, ground cover and blue grama composition were examined for all years except 1973. Runoff was not considered because it was relatively small. There were 5 sets of data (5 years) for correlations involving precipitation and yield, 6 sets for those involving previous season precipitation and ground cover or percent blue grama, and 7 sets for correlations involving current season precipitation and ground cover or percent blue grama. Yields used in correlations were those from treatment 2. Ground cover and blue grama composition data used were treatment averages.

Correlation coefficients for the above relationships (Table 7) show that yield is related more closely to precipitation received during the current than during the previous season. Conversely, ground cover and percent of blue grama reflect precipitation during the previous rather than the current season. These relationships support the premise that tiller primordia are differentiated under growth conditions of the previous year but expressed during the current season.

Several grazing management practices were reinforced by the results of this study. Blue grama and buffalograss are the primary elements of the plant matrix in the Southern Great Plains, although certain opportunistic plants may appear with favorable growing conditions. Precipitation is used most efficiently if the forage produced is harvested regularly. Also, nutrient requirements of animals for protein and phosphorus would be more adequately met with frequent harvesting during the summer growth period than with year-long or winter grazing. Winter grazing probably would require supplementation.

Table 7. Correlation of yield, ground cover, and percent blue grama with precipitation.

Growing season of precipitation	Dependent variable	Correlation coefficient: Sample	Correlation coefficient: Req. for sig. at 10% level
Current	Yield	.7977	.8054
Previous	Yield	–.5585	.8054
Current	Ground cover	.1371	.6694
Previous	Ground cover	.6918	.7293
Current	Percent blue grama	.3376	.6694
Previous	Percent blue grama	.7765	.7293

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