Big Sacaton Riparian Grassland Management: Seasonal Grazing Effects on Plant and Animal Production

J.R. Cox
USDA-ARS
Tucson, AZ

R.L. Gillen
Oklahoma State University
Stillwater, OK

G.B. Ruyle
University of Arizona
Tucson, AZ

Abstract. F1 Brahman steers annually grazed the same big sacaton (*Sporobolus wrightii* Monro) pastures in either spring (May 1–June 12), summer (July 1–August 12), or fall (September 1–October 12) for three years. Green forage accumulated gradually in spring, accumulated rapidly in summer, and declined gradually in fall, but mean daily steer gains averaged 1.5, 0.8, and 0.5 lb/animal on spring, summer, and fall grazed pastures, respectively. Spring gains were superior because green forage quality was greatest when plants initiated growth in spring. Summer gains were directly affected by green forage quantity, and green forage quantity was dependent on highly variable summer rainfall amounts. Fall gains were consistently low because forage quality declines rapidly in fall when green forage transfers to dead forage. In the three years, more than 80% of the green forage disappeared during spring grazing but pastures recovered in subsequent summer growing seasons. If the land manager wishes to maximize animal production without damaging the renewable natural resource (plant production), it is recommended to graze big sacaton grasslands in spring, avoid these riparian grasslands in dry summers, and discontinue fall grazing.

Introduction

Before 1880, big sacaton (*Sporobolus wrightii* Monro) stands, in lowland areas, received additional moisture in the form of runoff from nearby uplands and flood water from more distant mountainous areas (Wooten and Standley, 1911). Between 1890 and 1940, the processes that supplied additional soil moisture were reduced due to gully and channel erosion, and by 1950 the big sacaton area of distribution declined 95% (Humphrey, 1960). The remaining stands are important to land managers because in summer they annually produce large green biomass quantities (1,500–3,200 lb/A; 1,680–3,580 kg/ha) that slow runoff, enhance infiltration, trap sediments, and provide cover and forage for wildlife and cattle (Bock and Bock, 1978; Cox and Morton, 1986; Hubbell and Gardner, 1950).

Big sacaton green forage is present throughout the year, but green forage utilization is limited by dead standing forage (Griffiths, 1901). Burning and mowing remove dead standing forage, but for two or more years after either treatment in spring, summer, or fall, green forage production is less than in untreated areas (Cox, 1988). These treatments may be partially responsible for the decline of big sacaton grasslands, and Cox and Morton (1986) recommended that both be discontinued.

Gramagrasses (*Bouteloua spp.*) normally predominate on uplands surrounding big sacaton riparian grasslands (Humphrey, 1960). In spring and early summer, when gramagrasses are inactive, land managers believe that cattle utilize big sacaton green forage (Griffiths, 1901). In mixed big sacaton-gramagrass pastures, however, Brahman heifers and steers prefer dead gramagrass and avoid big sacaton green forage (Cox and Morton, 1986) even though green forage quality is equal to alfalfa (*Medicago sativa* L.). Hence, fencing is needed to separate the two grasslands to prevent over utilization of gramagrasses and under utilization of big sacaton (Cox, 1984).

In order to evaluate the animal-carrying capacity of big sacaton grasslands, ecologic studies are needed to quantify stand dynamics (Cox, 1984; 1985; 1988) and grazing studies are needed to evaluate animal performance (Haferkamp, 1982). The objective of this study was to evaluate the effect of annual spring grazing, annual summer grazing, and

Address reprint requests to: J.R. Cox, USDA-Agricultural Research Service, Aridland Watershed Management Research Unit, 2000 E. Allen Road, Tucson, AZ 85719, USA.

annual fall grazing on big sacaton growth and animal gains. The authors used big sacaton basal areas and densities as grazing tolerance measures, forage disappearances as animal carrying or grazing capacity indicators, and animal and pasture gains as forage quality indicators.

Study Site

A study site representative of big sacaton grasslands in the southwestern United States and northern Mexico was selected 50 miles (80 km) south of Tucson in southeastern Arizona. Elevation is 4,490 ft (1,365 m), and soils are Pima silty clay loam, with a sandy loam subsoil, thermic Typic Haplustoll (Richardson et al., 1979). Soils are recent alluvium, weathered from mixed rocks, moderately alkaline, slightly calcareous, and greater than 6 ft deep.

Annual precipitation in the past 50 years varied from 7–36 in. (178–914 mm) (Sellers and Hill, 1974; Climatography of the United States (Arizona), 1982). Mean annual precipitation is 14 in., 60% comes in summer and 40% in winter. Daytime temperatures average 86°F (30°C) in summer while nighttime temperatures are usually less than 32°F (0°C) in winter.

Between 1885 and 1935, big sacaton and gramagrass uplands at the study site were grazed year long by cattle and horses (Streets and Standley, 1938). In 1935, 400 A (160 ha) were fenced (approximately ⅓ big sacaton and ⅔ gramagrasses) and until 1980 the pasture was either grazed in spring and winter by cows and calves or in spring, fall, and winter by horses (Cox and Morton, 1986).

Methods

In 1982, the gramagrass grasslands were excluded from the big sacaton grassland, and the big sacaton area subdivided into seven sections. Fence lines were constructed so that six sections were 10 A (4 ha) and one was 2 A. Big sacaton standing crops were similar in each pasture (3,200–3,900 lb/A; 3,585–4,370 kg/ha) but total forage (lb/pasture) was 5-times greater in the six 10-A pastures than in the small pasture.

In three 10-A pastures, big sacaton plants were spaced 6 ft apart and heights averaged 6 ft. In the three other large pastures, plants were spaced 3-ft apart and heights averaged 2.5 ft. Approximately one-half of the small pasture was dominated by each growth type.

One of the following treatments was applied annually to the same two 10-A pastures (one pasture with large plants and one pasture with small plants): 1) annual spring grazing (May 1–June 12); 2) annual summer grazing (July 1–August 12); 3) annual fall grazing (September 1–October 12); and 4) the 2-A pasture was an untreated and ungrazed control.

Plant Production

Standing crops of big sacaton were sampled on May 1, 8, 15, 22, 29, and June 5 and 12 on spring grazed pastures, on July 1, 8, 15, 22, 29, and August 5 and 12 in summer grazed pastures, and on September 1, 8, 15, 22, 29, and October 5 and 12 in fall grazed pastures. The control pasture was sampled on all dates. Sampling on May 1, July 1 and September 1 was to set stocking rates; which were based on a 60% target utilization of either green or total big sacaton forage. Sampling at all other dates was to document forage disappearance. Sampling on December 1 was to measure regrowth after livestock removal.

Twenty randomly selected 1.0 × 9.5-ft (0.3 × 2.9-m) sampling areas were located in each large pasture at each sampling date. Within the control pasture five 1.0 × 9.5-ft sampling areas were randomly selected in each big sacaton growth type. Big sacaton plants in each sampling area were harvested at the soil surface, hand separated into live (green) and dead (yellow and gray) biomass components, and dried in a forced draft oven at 105°F (40°C) for 48 h. Dry weight means were used to calculate biomass means for each vegetation component.

Frequent forage measurements from grazed and ungrazed pastures are useful indicators of forage accumulation and disappearance (Scarnecchia and Kothmann, 1986). Forage measurements, however, are highly variable when selected at random because minor topography changes have major effects on soil moisture and soil nutrients (Kalmbacher, et al., 1986). Ten permanent 100-ft transects were established in each large pasture, to document seasonal grazing effects on big sacaton basal area and density. For a general comparison, five 100-ft transects were located in each growth type of the control pasture. Since grazing occurred at different times during active growth, basal area and density measures were made in winter (December) when plants were least active.

Treatments were arranged in a factoral design. The three seasons were randomized in the two big sacaton growth types, but growth types were unreplicated within a season. Therefore, grazing affects on large and small big sacaton plants can not be evaluated. Green biomass, dead biomass, and standing crop measurements were repeated at weekly intervals in each seasonally grazed pasture.

Animal Production

The authors intended grazing to occur in spring, summer, and fall for three consecutive years. In 1985, however, grazing was discontinued because a wildfire defoliated all pastures on February 5. On May 1, July 1, and September 1, 1983–1984 and 1986, 40–55 F1 Brahman steers weighing 350–500 lb (159–227 kg), and ranging from 12–18 months in age were weighed, separated into three weight classes, and an equal class number assigned randomly to a pasture. Steers were reweighed on June 12, August 12, and October 12.

Initially we expected the two big sacaton growth types to: 1) grow in summer after spring grazing, 2) grow in late summer after summer grazing, and 3) grow in the following summer after fall grazing. Hence, stocking rates would be similar between growth types and seasons, and an analysis of variance (ANOVA) could be used to test for differences among seasons and years. Our assumption that growth types would respond similarly in seasons and years was incorrect, and during the study stocking rates ranged from 9–27 steers per pasture. Since environmental conditions and plant growth factors caused the unequal allocation of steers, animal gain differences between types, and among seasons and years cannot be tested with an unbalanced ANOVA. Therefore, weight gains are averaged between types and presented for seasons within the three years.

Results and Discussion

Green Forage Accumulation

In grazed pastures, green forage quantities were greatest ($P \leq 0.1$) in fall, intermediate in summer and least in spring, but green quantities among years differed only in summer. Therefore, green forage accumulation will be discussed by season.

Winter and early spring (January–April) precipitation was 65% above the long-term mean (3.8 in., 96 mm) in 1983, 15% below the mean in 1984, and 7% above the mean in 1986 (Fig. 1), but green forage production in spring was similar ($P \leq 0.1$) among years. Between January and mid-May, nighttime temperatures in big sacaton riparian grasslands range from 15–50°F (Cox, 1984), but temperatures below 55°F (13°C) limit plant growth even when soil moisture is available (Cox and Morton, 1986).

Green forage accumulated rapidly after July 15, and in the three summers, green forage in grazed pastures peaked on July 29 and in the ungrazed pasture on August 12 (Fig. 2). Green forage peaks, however, were dependent on the amount and distribution of summer rainfall (Fig. 3). Winter and early spring precipitation was above the mean in 1983 but during the summer grazing trial, rainfall was about 50% (4.4 in.) below the mean (8.4 in.). Summer storms occurred at irregular intervals (5–10 days apart), amounts ranged from 0.2–0.5 in., surface soils dried in 1–2 days, and green forage on July 29, 1983 was 500 lb/A (560 kg/ha) in the summer graze pastures. Between July 27 and August 7, rainfall totalled 2.3 in., but the trial ended before additional green forage was produced.

Between June 15 and August 15, 1984 rainfall exceeded the mean (8.4 in.) by 20%, storms occurred at 1–5 day intervals and amounts ranged from 0.4–1.5 in. In the summer and the ungrazed pastures green forage averaged 1,100 lb/A (1,232 kg/ha) when steers entered on July 1. On July 29, green forage had doubled (2,200 lb/A) in the grazed pastures and quadrupled (4,400 lb/A) in the ungrazed pasture. Peak green forage (4,800 lb/A) in the ungrazed pasture on August 12, 1984 exceeded other reported peaks in Arizona (Cox, 1985) and in West Texas (Gavin, 1982) by 1,500 lb/A.

Thunderstorm activity began in late May 1986 and abundant green forage was expected on July 1. However, when steers entered summer pastures, green forage was the same as in 1984 (1,100 lb/A). It was believed initially that the February 1985 wildfire had influenced summer production in 1986, but the 1980–1986 precipitation records and green forage production data from burned and unburned areas (Cox, 1988; Cox and Morton, 1986) suggest an alternative explanation. In 1986, early summer storms were spaced at infrequent intervals (5–15 day intervals), amounts ranged from 0.1–0.5 in., relative humidity was low, and soil moisture evaporated before big sacaton initiated growth. In 1984, however, midsummer storms occurred frequently (1–5 days), amounts ranged from 0.7–1.5 in., relative humidity was high (greater than 60%), and surface soils remained wet for 6–15 days.

Fall precipitation was five times the long-term mean (2.5 in., 63 mm) in 1983, equal to the mean in 1984, and 44% below the mean in 1986. Rapid growth was expected in fall 1983 but fall green forage production was similar ($P \leq 0.1$) among years, even though variability on some sampling dates was greater than in summer. Nighttime temperatures dropped below 55°F (13°C) on approximately September 15, in the three years and irrespective of soil moisture conditions, green forage was transferred to dead forage.

Green Forage Disappearance

Approximately 80% of the green forage present in spring pastures disappeared during the three spring trials, while green forage in the ungrazed pasture more than doubled (Fig. 2). Green forage disappearance, calculated as the difference between green forage amounts in grazed and ungrazed pastures on June 12, averaged 87% in the three years and exceeded our desired level (60%) by 27%.

Green forage disappearance on August 12 (summer pastures), was 97% in 1983, 52% in 1984, 62% in 1986, and averaged 70% in the three years. Between July 1–22, green forage was dispersed in dead forage and steers appeared to equally utilize both green and dead components. In late July and August, steers appeared to graze only big sacaton green forage because dead forage disappeared when the probabilities of high nighttime temperatures, relative humidity and rainfall peaked (Cox, 1984; 1985; 1988).

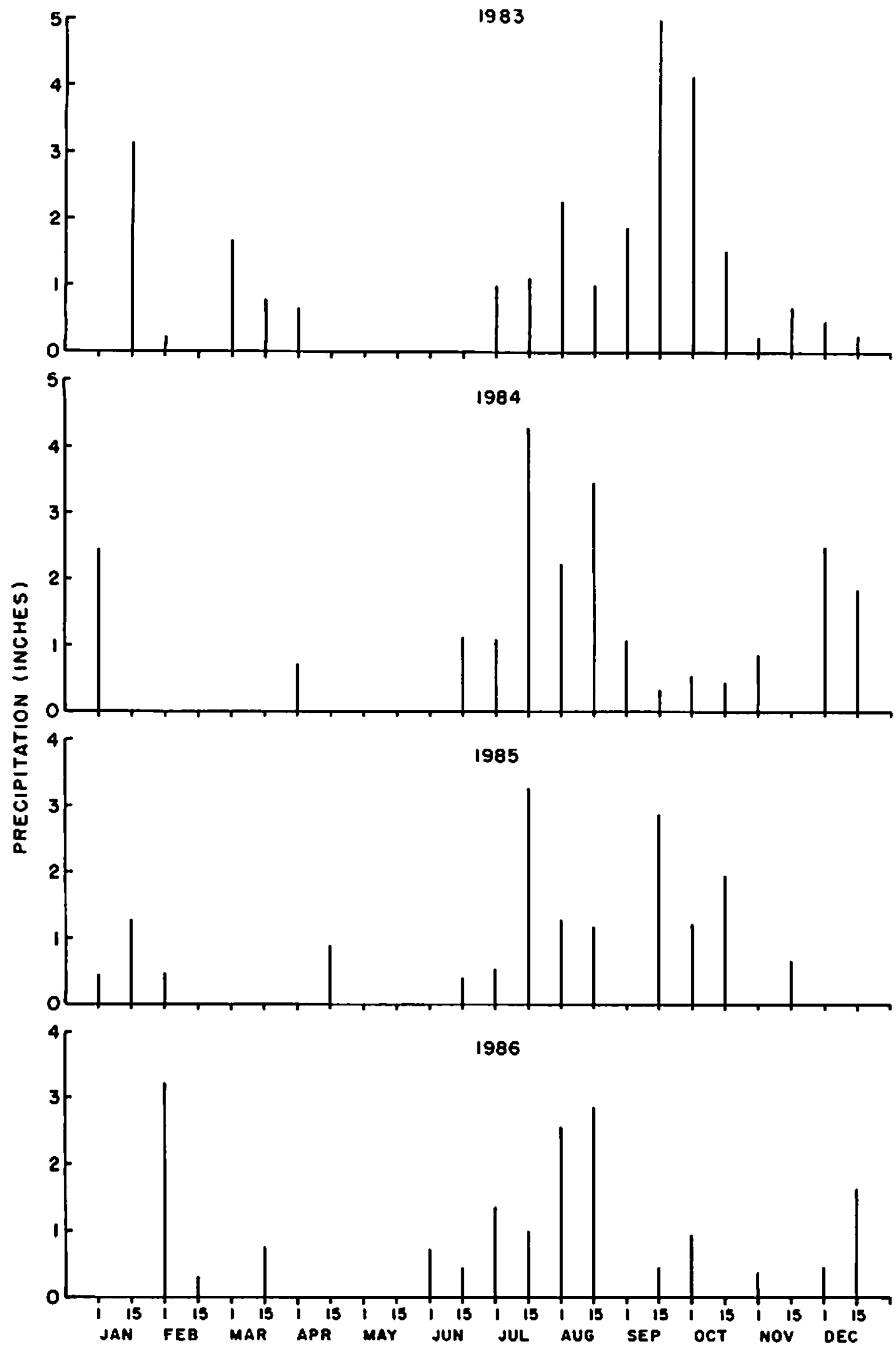

Fig. 1. Bimonthly precipitation amounts at a big sacaton grassland site in southeastern Arizona between 1983–1986. Conversion Factor: inch × 25.4 = mm.

In fall and control pastures, big sacaton green forage disappeared at about the same rate in each of the three years (Fig. 2). Trend similarities between the fall and control pastures suggest that steers are utilizing forage resources other than big sacaton. Hence, the common belief that cattle avoid big sacaton in fall (Griffiths, 1901). Daily animal observations during the fall trials indicate that other forages are unavailable and steers are grazing big sacaton. If it is assumed that: 1) steers are grazing big sacaton, and 2) green forage disappearance trends are similar in fall and control pastures then, the green to dead forage transfer when fall nighttime temperatures drop below 55°F (13°C) must occur more rapidly than steers can utilize either green or dead forage.

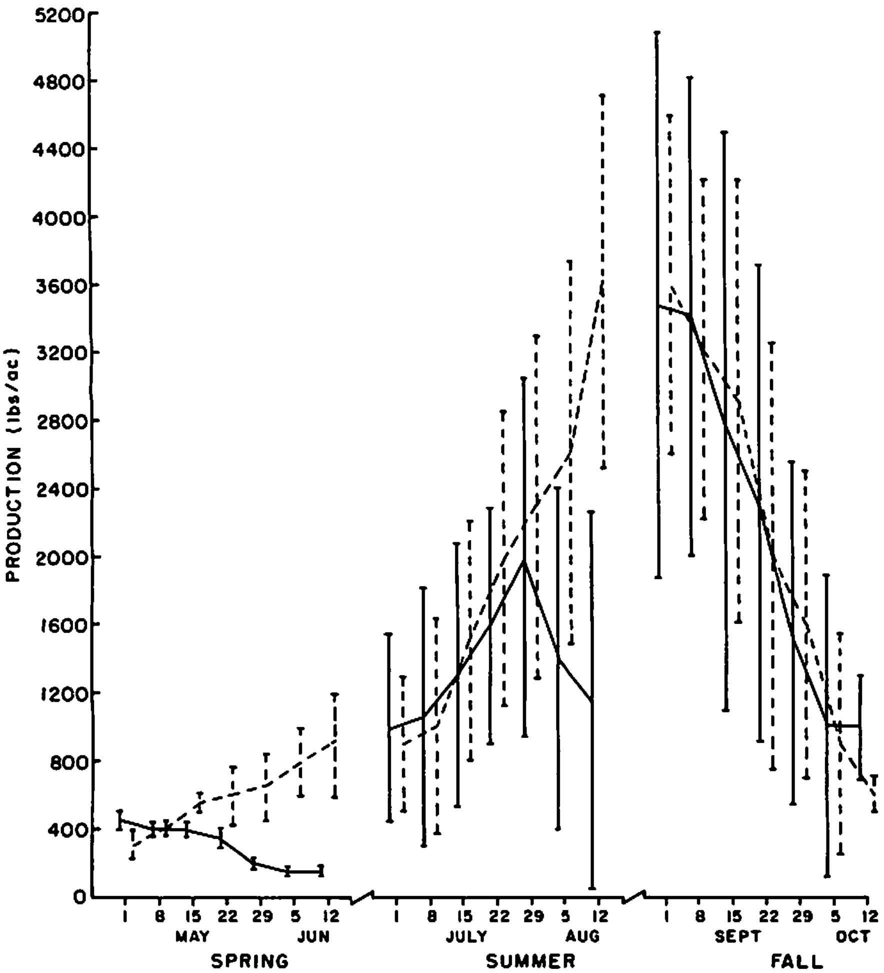

Fig. 2. Three-year means and standard errors for big sacaton green forage in spring, summer, and fall grazed (——) and ungrazed (---) pastures. Standard error notations are offset (grazed and then ungrazed) for each week. Green forage amounts in grazed pastures differed ($P \leq 0.1$) among seasons and among years. Conversion Factor: lbs/A × 1.12 = kg/ha.

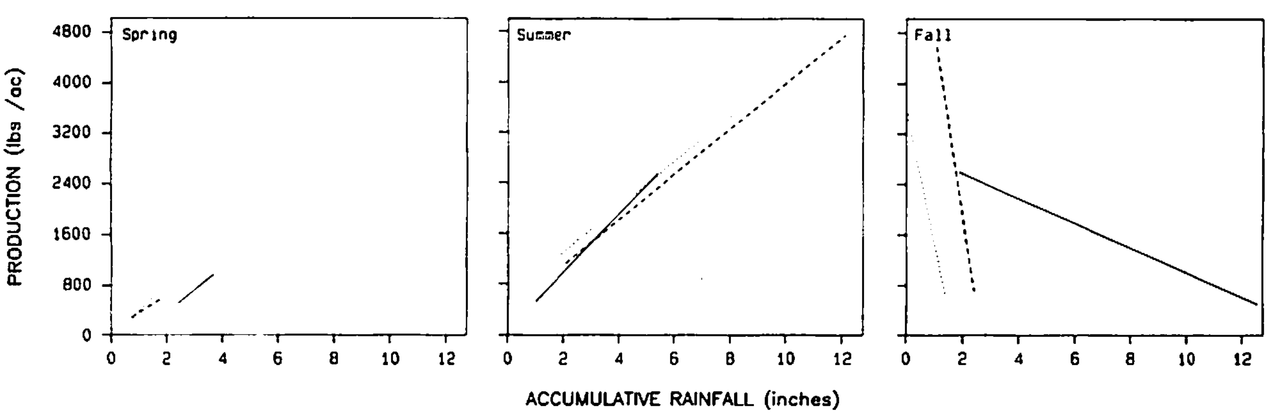

Fig. 3. Relationships between big sacaton green forage productions and accumulative precipitation for three seasons and three years: 1983 (——); 1984 (---); 1986(· · ·).

Total Forage

Big sacaton total forage (green plus dead) quantities were similar ($P \leq 0.1$) among seasons and among years, but differed among dates. Mean total forage for the three years averaged 3,600 lb/A (4,032 kg/ha) when steers entered the three seasonal trials, and 1,200 lb/A when steers were removed (Fig. 4). Mean disappearance averaged 66% among the three seasons, and utilization exceeded our target (60%) by 6%.

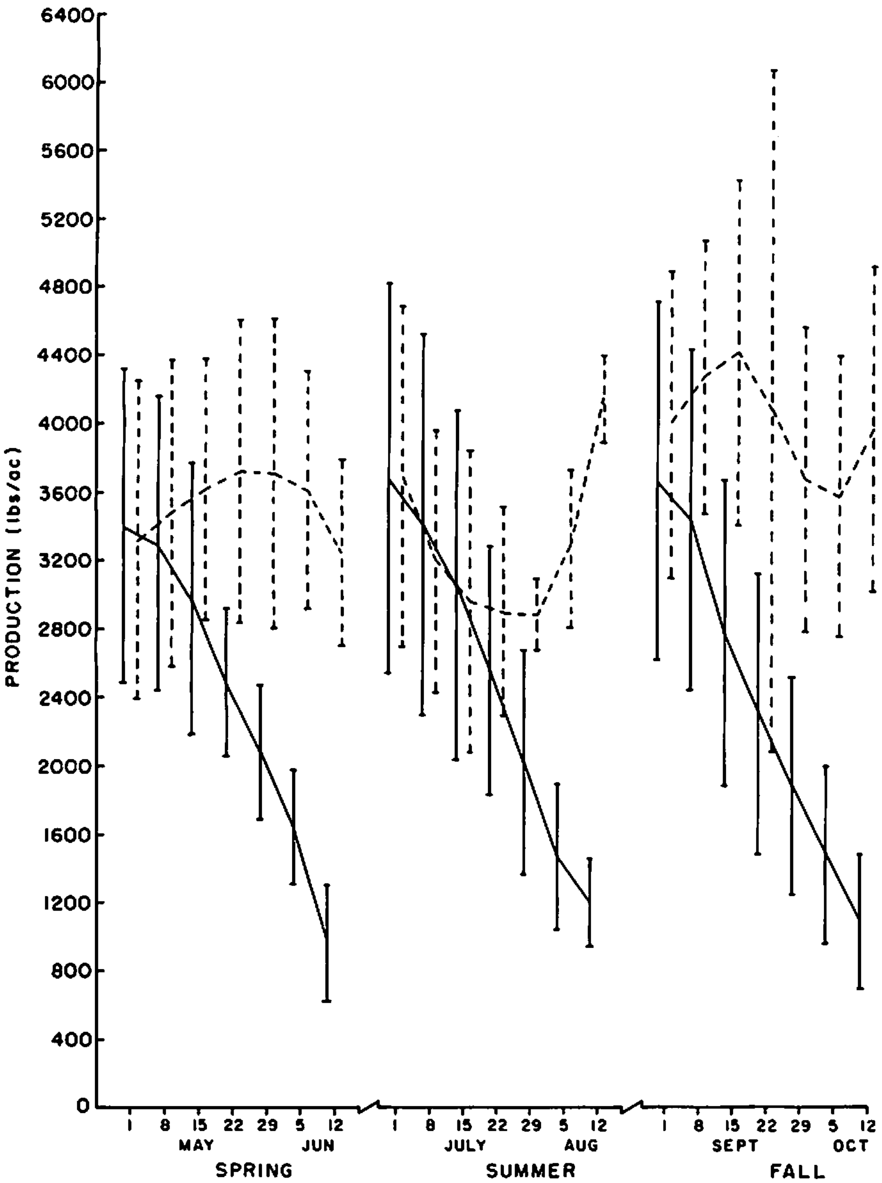

Fig. 4. Three-year means and standard errors for big sacaton total forage (green plus dead) in spring, summer, and fall grazed (——) and ungrazed (---) pastures. Standard error notations are offset (grazed and then ungrazed) for each week. Total forage amounts in grazed pastures differed ($P \leq 0.1$) only among dates. Conversion Factor: lb/A × 1.12 = kg/ha.

Basal Area and Density

In each of the seasonally grazed pastures, big sacaton basal areas and densities increased between 1982–1986 (data not shown), but increases were not significant ($P \leq 0.1$). In the February 1985 wildfire, all big sacaton forage was consumed and in the following seasonal grazing trials, steers had access to crowns which had been previously protected by dead leaves and dead seed stalks. The fire and hoof action destroyed portions of the crowns, and a plant reported as a single individual in 1982–1985 was reported as two or more in 1986.

Grazing Effects on Regrowth

In winter following spring, summer, and fall grazing, big sacaton total forage varied from 400–4,600 lb/A (448–5,152 kg/ha) in the three years. Green and dead forage in spring, summer, and ungrazed pastures varied from 230–320 lb/A and 3,400–4,300 lb/A, respectively. Green and dead forage in fall pastures varied from 10–170 lb/A and 400–1,600 lb/A, respectively, but at the end of summer (in the following year) forage in fall pastures was about equal to the ungrazed pasture.

Animal Production

Spring stocking rates were unchanged while summer and fall stocking rates declined in the three years (Table 1). In 1983, big sacaton total forage (green plus dead) was about equal in the two spring, two summer and two fall pastures, and all pastures received about the same steer numbers. In 1984 and

Table 1. Stocking rates, daily gains, and total pasture gains of F1 Brahman steers grazing big sacaton for 42 days during either spring, summer, or fall 1983, 1984, and 1986[a]

Treatment	Stocking rate (head/A)[b]			Daily steer gains (lb/animal)[b]			Total pasture gains (lb/A)[b]		
	1983	1984	1986	1983	1984	1986	1983	1984	1986
Spring grazing	1.3	1.3	1.3	2.3	1.1	1.2	130	62	67
Summer grazing	1.7	1.3	1.1	−0.3	1.6	1.0	−22	90	48
Fall grazing	1.7	1.3	1.2	0.1	0.6	0.7	7	34	35

[a] Steers entered pastures on either May 1, July 1, or September 1.
[b] Conversion factors: head/A = head/0.45 ha; lb/animal = 0.45 kg/animal; lb/A = 1.12/ha.

1986, total forage declined in pastures with small plants and increased in pastures with large plants. Total head per pasture varied from 9–15 and 19–26 for pastures with small and large plants, respectively.

Spring daily (1.5 lb, 0.7 kg) and total pasture (86 lb, 39 kg) gains, averaged among years, were approximately 2-times greater than in summer and 3-times greater than in fall. While green forage production was greatest ($P \leq 0.1$) in fall, intermediate in summer and least in spring. The apparent inverse relationship, however, is invalid because gains were highly variable among seasons and among years (Table 1).

Seasonal precipitation amounts may either have a positive or negative effect on steers grazing big sacaton riparian grasslands (Figs. 1, 2, and 3; Table 1). When winter-early spring precipitation was above-average (1983) and summer precipitation was above average (1984), big sacaton green forage production exceeded previously reported amounts (Cox, 1984; Gavin, 1982) and steer daily gains varied from 1.6–2.3 lb/animal. When precipitation was average (spring 1986) or slightly below-average (spring 1984, summer 1986) green forage production declined 20–30%, and daily gains averaged 1.1 lb/animal. In summer 1983, precipitation was 50% below average, green forage production was 75% below the 1980–1983 mean (Cox, 1984) and daily gains averaged −0.3 lb/animal. In contrast, above-average fall precipitation in 1983 leached nitrogen from big sacaton green leaves (Cox, 1988), enhanced the abundance of fly and mosquito swarms (USDA-ARS, unpublished data), and daily gains were unchanged during the 42-day trial. Whereas, in 2 typical dry falls (1984 and 1986), daily gains varied from 0.6–0.7 lb/animal.

Management Implications

Big sacaton green forage quantities were greatest ($P \leq 0.1$) in fall and summer pastures, and least in spring pastures. Animal performance, however, was generally better in spring than in summer and fall pastures (Table 1) because green forage quality peaks in May and declines between June and October (Cox, 1988). Since steers in spring pastures were used in subsequent summer and fall pastures, it can be argued that the previous grazing period influenced animal performance. It is realized that compensatory gains are affected by previous grazing history, but economics limited the ability to purchase a new herd for every seasonal trial.

In 1983, spring steer gains were approximately twice those recorded in either spring 1984 or spring 1986 (Table 1). In the spring in 1984 and the spring of 1986, surface soils were dry; while in 1983 surface soils were moist when nighttime temperatures approached 55°F (13°C). Residual winter-early spring soil moisture stimulated active growth in the final 15 days of the spring 1983 trial and steers grazed green forage; while in 1984 and 1986, most green forage disappeared before the spring trial ended.

Summer steer gains generally exceeded fall gains, except in 1983, but gain extremes were more pronounced in summer than in spring and fall (Table 1). In southeastern Arizona the amount and distribution of summer rainfall is highly variable (Sellers and Hill, 1974) and summer rainfall variability directly affects big sacaton green forage production (Figs. 1, 2, and 3). Because summer green forage production increases as rainfall amount increases and summer rainfall is inconsistent among years, gain extremes for steers in summer pastures should have been anticipated. Since plant growth occurs after steers enter summer pastures, the manager is advised to base stocking rates on July 1 total forage amount and adjust numbers up or down if summer rainfall is either above or below normal.

Initially it was expected that fall steer gains would exceed summer and spring gains because green forage production in fall exceeded summer and spring forage production. The assumption that steers in fall pastures would gain more rapidly was incorrect because green forage quantity and quality declines in mid-September when nighttime temperatures drop below 55°F (13°C). It is recommended that fall grazing be discontinued because: 1) steer gains were consistently low (Table 1) and, 2) fall defoliation leaves big sacaton crowns exposed to below freezing temperatures. Crown exposure in winter may reduce big sacaton green forage production for four or more years (Cox, 1988) or kill plants (USDA-ARS, unpublished data). In a normal dry fall, some forage may be harvested with bulls or dry cows. When fall precipitation is above-normal the manager should avoid these riparian grasslands because insects are abundant and forage quality is lower than in a normal dry fall.

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