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Abstract
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Keywords
Agronomy, Animal management and forage, Economic and environmental impacts

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

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Background
Switchgrass and big bluestem were two major species in the original tall grass prairies of North America and they supply high-quality forages during the hot, dry summer months. Both these grasses work well for summer pasture and hay utilization, but switchgrass is more popular because its small seeds make seeding and uniform stand establishment easier to accomplish. Grazing studies done in several states have documented the potential contributions of perennial, warm-season grasses to summer pasture compared to cool-season grasses.

Bud development and morphological development are important management considerations for warm-season grasses. Some studies suggest that rotational grazing designed to remove the growing point of the tillers might result in a more productive season. However, early removal of tillers could also reduce potential growth and productivity.

One study stated that big bluestem may be the single best warm-season grass for the north central United States because it remains palatable for a long time and normally reaches heading stage two to three weeks later than switchgrass. It is, however, harder to establish than switchgrass. Other research reports that early partial defoliation of switchgrass causes no serious problems and may even improve some qualities for livestock use.

Four specific objectives of this project were:
1) To compare beef steer performances from rotational vs. continuous grazing systems of warm-season grasses
2) To compare beef steer performances on switchgrass vs. big bluestem pastures for each grazing system
3) To record total season beef steer performance for spring (cool-season pasture) and summer (warm-season pasture)
4) To evaluate plant responses to grazing.

Approach and methods
The experiment site at the Iowa State University Western Research Farm near Castana, Iowa, was divided into four main pasture areas; in 1991 two were seeded to 'Cave-in-Rock' switchgrass and two to 'Roundtree' big bluestem. The switchgrass pastures were reseeded in 1992 to achieve a more uniform stand. Eight paddocks were created and two of each were randomly assigned a grazing treatment; either switchgrass grazed rotationally, switchgrass grazed continuously, big bluestem grazed rotationally, or big bluestem grazed continuously. Pastures were fertilized annually in early spring before grass growth with 100 to 120 pounds per acre of N.

In 1993, for the continuous treatment, the switchgrass paddock was grazed for 42 days and the big bluestem for 28 days. The rotational paddocks were both grazed for 14 days initially, then given a 28-day rest and regrowth.
period before being grazed a second time. A similar schedule was followed in 1994. The actual grazing periods and steer stocking rates for all treatments were determined by the growth stage of the grass and available herbage.

**Animal response measurements:** The grazing herd included fall-born steers of 225-275 kg. (500 to 600 lbs.). They were weighed at the introduction to and withdrawal from warm-season paddocks and at two week intervals when grazing.

**Plant response measurements:** Grazing restriction cages (GRCs) were constructed to house grass samples unaffected by the grazing animals. Measurements were taken weekly during grazing periods, both inside and outside the GRCs, to provide data on forage intake by steers and changes in forage quality over the grazing period.

**Grazing heights:** Target grazing heights varied with grazing treatment and period. Rotational grazing for the first period began when vegetation was 12 to 15 inches high and ended when vegetation was grazed to a 4-inch height. The second grazing period, begun after four weeks rest, ended when stubble height was 8 inches for switchgrass and 6 inches for big bluestem. Continuous grazing of switchgrass began in late June and continuous grazing of big bluestem started about two weeks later. Continuous grazing for both grasses ended when most of the leaf blades had been selectively grazed, steers refused the trampled forage, and daily weight gains were no longer acceptable.

**Quality analyses:** The in vitro dry matter digestibility of herbage samples was determined by using the in vitro rumen fermentation system. Crude protein was determined by the Kjeldahl method.

**Results and discussion**

**Animal responses:** Steer average daily gain (ADG) over three years was .28 pounds/day greater for big bluestem than for switchgrass during the first period of rotational grazing. For the second rotational grazing period, steer ADG on big bluestem was 3.12 pounds/day or .68 pounds/day greater than that of steers dining on switchgrass, which is impressive for midsummer grazing. Gains of steers grazing warm-season grasses are even more impressive when compared with relatively low ADG for steers grazing cool-season pastures before grazing either the first or second period on warm-season paddocks. Steers on cool-season pasture diets gained as little as 1.29 pound/day before they grazed switchgrass in midsummer and .44 pound/day before they grazed on midsummer big bluestem.

Pasture carrying capacity was much greater for rotationally grazed switchgrass and big bluestem than for their continually grazed counterparts. Carrying capacity was 2.15 times greater for switchgrass under rotation rather than continuous feeding. Rotationally grazed big bluestem had a carrying capacity 2.58 times higher than the continuously grazed variety. The largest differences between grazing systems most likely result from more efficient utilization (less trampling) of forage and the higher-quality forage available under the rotational system.

Steer live-weight gain per acre (LWG) achieved on the rotational switchgrass paddocks was substantial. Over the project’s three years, animal gains on switchgrass averaged 472 pounds/acre. The totals for rotationally grazed big bluestem were somewhat lower (354 pounds/acre), but still good. It is especially

Big bluestem was a major species in the original tallgrass prairies of North America.
significant that these gains were achieved during grazing periods of only 35 to 48 days, respectively, for switchgrass and big bluestem. For the total grazing season, cattle grazing on the rotational switchgrass paddocks had LWGs 2.76 times higher than those on the continuous grazing sites. LWGs for steers on big bluestem were 1.81 times better on rotational than continuous grazing.

Plant responses: Researchers had hoped to measure plant responses for all three years. Weed and cool-season grass invasions during the third year resulted in very difficult and unreliable plant sampling, so no sampling was done in the third year.

Warm-season grass herbage was characterized at the initiation of grazing for each paddock. Tiller density varied for both grasses in both years studied, but the morphological development was very similar at the beginning of the rotational grazing in 1993 and 1994. The grazing of big bluestem was delayed for two weeks in an effort to graze both species at about the same stage of morphological development. However, even though big bluestem follows switchgrass by two weeks in development, the herbage quality is similar to that for switchgrass at the same approximate calendar date.

Plant canopy heights were measured as each grazing period began and at weekly intervals after that. The differences in canopy height that appeared were likely because of weather variability between years. Plant vigor in the second year of grazing has been shown to be somewhat less than the first grazing year, which would contribute to shorter canopies. Switchgrass reached its targeted minimum grazing height after two weeks of grazing in 1993, and after only eight days in 1994.

Grazing heights must be interpreted carefully. Trampling in the continuously grazed big bluestem made grazing heights difficult to correlate to actual steer consumption of foliage. Likewise, cattle stripped leaf blades from the continually grazed switchgrass while leaving many stems standing upright.

Herbage dry matter (DM) above the targeted minimum grazing height was measured both inside and outside the GRCs for each grazing system at the outset and at weekly intervals throughout the grazing period. These measurements helped determine suitable stocking rates for the pastures, as well as providing an estimation for the amount of forage consumed from week to week. This estimation cannot be made as effectively in a continuous grazing system because forage is trampled below the targeted grazing height.

For the early rotational grazing period, herbage DM decreased linearly during the two-week period for both switchgrass and big bluestem in 1993, and approached a value near zero in both cases. Herbage dry matter yield was similar for switchgrass in the first period of both years. By the second stage, DM in the GRCs was twice as great in 1993 compared with 1994, although DM within the pasture itself was similar for both years. Trends in rotational grazing systems illustrate the rapid growth of warm-season grasses during the summer and their rapid decline in productivity in August. Plants change Physiologically, either becoming reproductive or reducing their growth rates at this point.

Continuous grazing systems showed greatly differing amounts of DM between years. For switchgrass, DM was almost twice as great in 1994 than in 1993 for both cage and pasture measurements during the entire grazing period. Dry matter was much greater in 1994 than 1993 for big bluestem grazed continuously, but not to the degree of switchgrass.

For all systems during both years, steers were removed even though large amounts of DM remained in the paddock. Much of the remaining DM was low-quality stem material, and daily live-weight gains had become unacceptable.

Forage (herbage) quality was gauged in several areas. Extremely high herbage digestibility was measured during the early period of grazing for rotational systems. Switchgrass digestibility values were about 10 units higher than for big bluestem in 1993 and equal in
digestibility to high-quality alfalfa. The somewhat lower values for big bluestem illustrate the lower quality of big bluestem compared with that for switchgrass at similar growth stages. For the second period of rotational grazing, the digestibility measure of both grasses was still similar to that observed at the end of the first grazing period. This points up a major advantage for rotational grazing vs. continuous grazing. The early partial defoliation of warm-season grasses promotes midsummer regrowth that is less stemmy and more easily digestible.

During the same grazing period, continuous grazing systems were much lower in herbage quality than the rotational systems. Switchgrass and big bluestem herbage varied from 5 to 10 percentage units lower in digestibility under the continuous system. It should be noted that relatively low digestibility is not as serious as it might seem because livestock selectively strip leaves from stems and leaf digestibility is much greater than whole plant digestibility.

Very high crude protein (CP) concentrations were found weekly during both years in forages from the rotationally grazed paddocks. Early grazing period switchgrass CP levels were similar to those in high-quality alfalfa. One possible reason for the high CP levels in 1993 is that the paddocks were burned off earlier in the season and this can increase herbage CP as well as digestibility.

When the steers were returned to the rotational grazing paddocks (after a four-week rest and regrowth period), forage CP levels were similar to those when the steers were removed a month earlier. This suggests that early, intensive grazing forced plants to produce regrowth and new tillers. The new growth had a much greater leaf:stem ratio with higher protein and digestibility values. Levels of CP were much greater for rotationally grazed systems than for continuously grazed systems when compared at similar calendar dates.

Forage CP deterioration during the growing season varied between grass species, grazing systems, and years. Forage CP in the rotationally grazed switchgrass paddocks dropped linearly in the summer, until it reached about 11.5 percent and then stabilized. For rotationally grazed big bluestem, forage CP declined linearly in 1993 and fluctuated in 1994. Switchgrass grazed continuously declined in CP during the grazing period for both years, eventually to a rather consistent level of 9 to 9.5 percent. CP concentrations for big bluestem were lower in 1994 than in 1993; running about 3 percentage units less on any given day.

Conclusions

Results indicate that a major advantage exists for producers who adopt a rotational grazing management system similar to that used in this study. Benefits include:

1) a brief rest and regrowth period for the cool-season pastures,

2) an extended spring and early summer grazing period for the cool-season pastures with increased productivity of those pastures,

3) less trampling and waste in the warm-season pasture,

4) improved summer herbage quality of the warm season pasture,

5) an increase in both average daily gain and steer days of grazing per acre for animals on warm-season pastures, and

6) two to three times as much total steer gain per acre compared with that for continuous grazing.
Although a four-week rest and recovery growth period between the two periods of rotational grazing was used in this study, recent research information suggests that the rest period should be five to six weeks to allow plants to replenish total storage reserves. Close monitoring of the pasture, including grass tillering, canopy heights, grazing height changes during grazing period, and proper stocking rates is critical. Careful oversight will minimize weed and cool season grass invasion and maximize persistence, productivity, and quality of forages for pasture grazing.

**Implications**

Producers are more likely to retain warm-season grasses that were established as seeding on their highly erodible and fragile land in the ten-year CRP (Conservation Reserve Program) if it can be demonstrated that these pastures are productive, both in offering high-quality forage and in promoting animal growth. Additionally, farmers are more inclined to continue seedings of long-term perennial stands of warm-season grasses if the economic value is clear.

Most livestock producers—especially beef producers—would benefit from a diverse cool-season/warm-season pasture program. A very simple rotational grazing system consisting of a two-week short duration, intensive grazing period beginning June 1, followed by a four-week rest and recovery growth period (five to six weeks of rejuvenation now seems very important) offers many advantages. It can eliminate the serious forage trampling situation, provide an abundant supply of high-quality forage in summer when it is needed most, and also results in a tremendous increase in daily and seasonal livestock performance.

**Education and outreach**

Research results from this project were widely disseminated at sites ranging from two ISU classes to national professional meetings. Presentations were made at field days held at the Castana Western Research Farm in 1994 and 1996. Participants at the 1995 and 1996 Management Intensive Grazing Symposiums in Des Moines were informed about the study. Poster presentations were made at the 1996 ISU Agronomy Days and at the American Society of Agronomy annual meeting. An audience of about 400 at the American Forage and Grassland Council Annual Conference heard a presentation about the research findings. Steve Barnhart, ISU Forage Extension Agronomist, and Bob Dayton, State Agronomist with the NRCS, informed numerous contacts about the project.