Trampling effects from short-duration grazing on tobosa-grass range

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Abstract

Emergence of broadcast-seeded kleingrass (*Panicum coloratum* L. 'Selection 75') was compared for 2 seasons in short-duration grazed (SDG) areas and ungrazed exclosures in the Texas Rolling Plains in order to test the hypothesis that short duration grazing (SDG) increases seedling emergence. Kleingrass emergence was similar between treatments in both years. Emergence was unrelated to percent foliar cover of preexisting vegetation. Soil strength was greater in grazed areas in both years, but showed evidence of recovery between years. Trampling under short-duration grazing provided no beneficial effect on kleingrass emergence or soil strength in either year.

Key Words: seedling establishment, soil compaction, grazing management, *Panicum coloratum* L.

Hooves of grazing animals impart physical impact on rangeland soils and vegetation. Kind of animal, season and intensity of grazing, soil characteristics, and plant community influence the type and degree of impact. Rangelands do not benefit from long-term, excessive physical animal impact (Lull 1959, Reynolds and Packer 1963, Blackburn et al. 1982, Blackburn 1984).

Proponents of intensive rotational grazing systems cite beneficial effects from increased stocking densities. The "hoof action" of concentrated animals is said to improve soil hydrologic properties by breaking up crusts and increasing infiltration, thereby enhancing seedling emergence (Savory and Parsons 1980, Walter 1984). Recent studies of intensive rotational grazing systems have demonstrated detrimental impacts on soil-hydrologic properties such as infiltration rate, sediment production, and runoff (Blackburn 1984; Thurow et al. 1986; Warren et al. 1986a, 1986b, 1986c, 1986d; Weltz and Wood 1986).

Germination of a surface-lying seed depends on escape from predation and placement on a site which provides appropriate moisture and temperature conditions (Harper et al. 1965, Sheldon 1974). Modifications of soil structure and/or microtopography by animal trampling can influence the number of microsites available for germination. Trampling may improve the suitability for germination of one type of microsite but reduce the suitability of another (Stephens 1980, Eckert et al. 1986).

The ability of a seedling to emerge out of, or push roots through, soil depends on relative soil strength and moisture content as well as the emergence force exerted by the seedling (Hanks and Thorp 1957, Taylor 1971, Jensen et al. 1972). As the soil surface dries, soil strength increases, and emergence declines (Stephens 1980). Trampling may increase emergence of some species but decrease emergence of others (Stephens 1980, Wood et al. 1982, Dahl 1986, Eckert et al. 1986, Norton and Owens 1986). Factors other than trampling also influence seedling emergence. Wood et al. (1982) and Dahl (1986) considered the presence or absence of competing vegetation, and Stephens (1980) and Eckert et al. (1986) considered soil microsite characteristics important in determining emergence and establishment. Soil moisture before emergence and the ability of a species to germinate under a wide variety of conditions may also exert greater influence than trampling (Graff 1983, Dahl 1986).

This study evaluated selected impacts of short-duration grazing (SDG) on western Texas rangeland. Effects of SDG on soil-hydrologic properties have been studied in detail. Response of plant communities to SDG on a relatively large spatial scale has also been investigated (Thurow et al. 1988 and references therein). Vegetation processes underlying observed community-level changes have received considerably less attention. Therefore, our primary hypothesis stated that trampling under SDG does not enhance seedling emergence; this was tested using broadcast-seeded kleingrass (*Panicum coloratum* L. 'Selection 75') as a bioassay. An additional hypothesis stated that soil strength is not influenced by SDG.

Materials and Methods

Research was conducted in 1985 and 1986 at the Texas Tech Experimental Ranch (101° 11′ W., 32° 58′ N.) 10 km southeast of Justiceburg, Garza County, in the Texas Rolling Plains. Regional climate is semiarid, with most of the 490 mm of average annual precipitation falling from May to October (NOAA 1985). Long-term climatological data are not available for the recently established Experimental Ranch. Study plots were located on a clay flat range site dominated by tobosagrass [*Hilaria mutica* (Buckl.) Benth.] and alkali sacaton [*Sporobolus airoides* (Torr.) Torr.] with scattered honey mesquite (*Prosopis glandulosa* var. *glandulosa* Torr.) and plains prickly pear (*Opuntia polyacantha* Haw.). Soils were nearly level Stamford clays (fine, montmorillonitic, thermic Typic Chromusterts) with a high shrink-swell potential, intermixed with small areas of Vernon clay loams (fine, mixed, thermic Typic Ustochrepts) (Richardson et al. 1965).

Before 1984, the site was moderately and continuously grazed. As part of a large research project, it was burned in February 1983 and sprayed in July 1983 with triclopyr [((3,5,6-trichloro-2-pyridinyl) oxy) acetic acid]. In 1984 a six-pasture short-duration grazing system was initiated. The 14-ha study pasture was stocked with Hereford/Angus crossbred steers at 1.7 AUM/ha in 1985 and 1.2 AUM/ha in 1986 for 3 grazing cycles between mid-April and mid-July each year. Recommended stocking for moderate, year-long continuous grazing on this site is about 0.8 AUM/ha. Sixty and 42 yearling steers were used in 1985 and 1986, respectively. Stocking rate each year and length of grazing and rest periods within years were adjusted to forage availability. In both years, the first 2 grazing periods were 7 days, followed by rest periods of 35 and 21 days in 1985 and 33 and 30 days in 1986. A final grazing period of 3 days in 1985 and 2 days in 1986 occurred before removal of all animals.

Immediately before grazing each season 128, 0.28-m² plots, arranged in a randomized, complete block design with 8 blocks, were broadcast-seeded with kleingrass at 8.6 kg pure live seed/ha. Kleingrass was selected because of its adaptation to the soil and rainfall conditions of the site. Seeding rate was intentionally heavy

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Manuscript accepted 28 June 1989.

to provide adequate emergence to test treatment effects. Half the plots in each block were located in randomly placed ungrazed exclosures. Blocks were relocated and new plots established for the second grazing season. Plots were located in a 2-ha area about 550 m from the watering point of the 800-m long triangular pasture. Grazed plots were marked below-ground with metal stakes to avoid artificially attracting cattle and augmenting trampling. A metal detector was used to locate plots on sample dates (Weigel and Britton 1986). Kleingrass seedlings grown in greenhouse pots were used to aid field identification. Plots were monitored twice-weekly for kleingrass and seedlings were counted following each emergence.

Vertical black-and-white photographs taken with a 35-mm camera and 50-mm lens from 1.5 m above each plot were used to estimate foliar cover of individual plots. A dot-grid overlay (50 dots/grid) was used to estimate cover on each photograph. These data were used to evaluate the effect of vegetative cover on kleingrass emergence.

A proving-ring penetrometer (Soiltest CN-970) was used to measure soil strength (MPa) before and after each grazing cycle each year. Soil strength is strongly correlated with soil bulk density, a measure of soil compaction (Gifford et al. 1977). Balph and Malechek (1985) found that livestock in a SDG system avoided trampling elevated grass tussocks, so penetrometer samples were taken only from bare soil interstices. Immediately before and after each grazing cycle, 640 penetrometer readings (80/block) were taken in groups of 20 closely spaced samples. In 1986, 3 of every 20 readings on dates after grazing began were taken in visible cattle hoofprints. This frequency of sampling corresponded to actual percent cover of hoofprints estimated by line-intercept sampling.

Trampling intensity was estimated by measuring hoofprint intercepts along 16 randomly located 10-m line trasects immediately following the first 2 grazing periods each year. Duncan's New Multiple Range Test was used to compare hoofprint intercept means for each date. Means for the grazing period immediately before each emergence event are reported.

Kleingrass emergence and soil strength data were averaged over subsamples (4 plots/average for kleingrass and 20 penetrometer readings/average for soil strength). These data were tested for normality at each date with the Shapiro-Wilk W-statistic (Shapiro and Wilk 1965). Block-treatment interaction for each date was tested using Tukey's single-degree-of-freedom test for nonadditivity at the 90% level of significance (Steel and Torrie 1980). In 1985, 3 of 4 data sets of soil strength demonstrated significant interaction and were transformed using the Anscombe-Tukey power transformation (Anscombe and Tukey 1963). Kleingrass emergence and soil strength data were evaluated using analysis of variance for a randomized, complete block design with a sampling error. Duncan's New Multiple Range Test was used to compare soil strength data when treatments were divided into hoofprint and nonhoofprint means. Regression analysis was used to assess the effect of foliar cover on seedling emergence.

Results and Discussion

Adequate precipitation before and after seeding is critical in stimulating germination (Wester et al. 1986). Precipitation during this period was average in 1985 and 50% above average in 1986. Three distinct emergence events occurred during the study: 1 in 1985 and 2 in 1986. All emergence events followed 5-day periods in which precipitation occurred on at least 2 of the days (Table 1). Wester et al. (1986) indicated that such a pattern may serve as an environmental trigger for kleingrass emergence. Trampling intensity before the single 1985 emergence was higher ($P<0.05$) than for the two 1986 emergences (Table 2) because of the higher stocking rate in 1985.

Table 1. Kleingrass seeding and emergence dates and daily precipitation, Spring 1985 and 1986.

Date 1985	Precipitation	Date 1986	Precipitation
	---(mm)---		---(mm)---
21 April	9.1	27 March	seeding
28 April	seeding	02 April	16.5
28 April	30.5	06 April	7.6
06 May	10.4	19 April	56.6
08 May	11.2	24 April	4.1
13 May	5.1	25 April	emergence
16 May	17.5	25 May	9.6
17 May	2.0	26 May	10.7
21 May	10.2	27 May	27.4
22 May	8.9	30 May	35.6
25 May	emergence	01 June	33.5
05 June	42.2	03 June	11.9
06 June	16.3	05 June	4.8
11 June	15.0	06 June	emergence
		17 June	23.9
		19 June	38.9

No difference ($P>0.15$) in seedling emergence between grazed and ungrazed treatments was found in either year (Table 2). Foliar cover of individual plots did not influence seedling emergence ($P>0.15$) for any date. Graff (1983) obtained little or no emergence of several broadcast-seeded grass and forb species subjected to trampling under 2 levels of SDG unless competing vegetation was suppressed with herbicide prior to seeding. Seeded into a stand of established perennial grasses, no kleingrass survived to establishment in either year in our study, probably as a consequence of insufficient post-emergence rainfall (no precipitation for 11-30 days post-emergence) and competition from perennial plants. Foliar cover of perennial grasses averaged 14% (grazed) and 18% (ungrazed) in 1985 and 20% (grazed) and 29% (ungrazed) in 1986. In natural systems, many plants emerge, but few survive (Harper 1977). Virtually all seedlings on all emergence dates died in the 2- to 3-leaf stage 3 to 7 days after emergence.

Table 2. Hoofprint intercept means (SE) by date and mean (SE) kleingrass seedling density by date and treatment, 1985 and 1986.

Emergence date	Hoofprint intercept[1]	Seedling density[2]	
		Grazed	Ungrazed
	———%———	———(seedlings/0.28m²)———	
25 May 1985	18.2 (2.6) a	7.6 (0.7)	6.6 (0.6)
25 April 1986	11.3 (1.8) b	8.5 (1.1)	10.7 (1.3)
6 June 1986	14.1 (1.6) b	10.3 (0.8)	12.5 (0.8)

[1]Hoofprint intercept (%) = total hoofprint intercept (cm)/total transect length (cm), n = 16 transects/mean; means in column followed by the same letter are not different ($P>0.05$).
[2]Seedling means in same row are not different ($P>0.05$), n = 64/mean.

Soil strength did not differ ($P>0.40$) between treatments before grazing in 1986 (Table 3). There was no pregrazing sample in 1985. Once grazing began, soil strength in the grazed treatment was higher ($P<0.0001$) than in ungrazed areas for all 1985 dates and 4 of 5 1986 dates. Uniformly low soil stength in both treatments on 31 May 1986 was attributed to very wet soil conditions (soil moisture 25%) from over 80 mm of rain received immediately before sampling.

On 4 of 5 1986 post-grazing sampling dates, soil strength in hoofprints was greater ($P<0.05$) than in untrampled areas within the grazed treatment (Table 4). Soil strength in grazed, untrampled areas was not different from ungrazed areas on 3 of 5 dates. Soil strength differences between treatments (Table 4) were apparently caused by the contribution of a few hoofprints, which had high soil

Table 3. Mean (SE) soil strength by date, grazing cycle stage, and treatment, 1985 and 1986.

Year	Date	Grazing cycle stage	Soil strength[1] Grazed	Ungrazed	Prob > F
			----------MPa----------		
1985	06 May	post-1	0.55 (0.01)	0.42 (0.01)	0.0073
	09 June	pre-2	0.62 (0.01)	0.48 (0.01)	0.0001[2]
	18 June	post-2/pre-3	0.88 (0.01)	0.62 (0.01)	0.0001[2]
	08 July	post-3	0.92 (0.01)	0.67 (0.01)	0.0001[2]
1986	20 March	pre-graze	0.86 (0.01)	0.87 (0.01)	0.4064
	13 April	pre-graze	0.68 (0.01)	0.68 (0.01)	0.9341
	23 April	post-1	0.66 (0.01)	0.53 (0.01)	0.0001
	14 May	post-1/pre-2	0.93 (0.01)	0.71 (0.01)	0.0001
	25 May	pre-2	0.70 (0.01)	0.55 (0.01)	0.0001
	31 May	post-2/pre-3	0.22 (0.01)	0.21 (0.01)	0.2041
	16 July	post-3	1.13 (0.01)	0.85 (0.01)	0.0001

[1]n = 640 for each mean, untransformed means reported.
[2]Analysis on power-transformed data.

Table 4. Mean (SE) soil strength by date in hoofprints and areas witho hoofprints, 1986.

Date	Soil strength[1] Grazed Hoofprint	Non-hoofprint	Ungraze
	------------MPA------------		
23 April	1.07 (0.03) a[2]	0.59 (0.01) b	0.53 (0.01
14 May	1.48 (0.02) a	0.84 (0.01) b	0.77 (0.01
25 May	1.24 (0.03) a	0.60 (0.01) b	0.55 (0.01
31 May	0.24 (0.01) a	0.22 (0.01) a	0.21 (0.01
16 July	1.54 (0.03) a	1.06 (0.01) b	0.85 (0.01

[1]n = 96, 544, and 640, respectively, per treatment per date.
[2]Means within a row followed by the same letter are not different (P>0.05).

strength, in the grazed treatment.

The duration of trampling impact on soil strength was not specifically investigated. However, evidence of recovery from compaction between years was found. Soil strength in second-year plots, all located in areas grazed during year one, did not differ (P>0.40; Table 4) prior to second-year grazing. This recovery was attributed to the high shrink-swell potential of the clayey Vertisols of the site (Larson and Allmaras 1971). Other studies of compaction from grazing have demonstrated recovery after rest (Warren et al. 1986c), although more than one season may be needed to return to the pre-compaction condition (Orr 1975, Stephenson and Veigel 1987).

Suggesting that soil hydrologic condition and subsequent seedling emergence is universally improved by livestock trampling ignores the effects of soil type, soil water content, stocking rate, and vegetation type (Warren et al. 1986c). Trampling of sandy, crust-prone soils may reduce compaction (Graff 1983, Tainton 1985) while finer-textured soils may be damaged (van Haveren 1983). The impact of trampling of wet soil is more detrimental than trampling of dry soil (Warren et al. 1986d).

No beneficial effects on either emergence of broadcast-seeded kleingrass or soil strength were realized from seasonal SDG trampling at stocking rates 2.0 and 1.5 times higher than recommended in tobosagrass-alkali sacaton vegetation on clay soils. Conversely, trampling did not reduce kleingrass emergence relative to ungrazed areas. Soil compaction, as measured by soil strength, increased in grazed areas. Presumably, soil hydrologic properties related to soil surface condition, such as infiltration rate, sediment production, and runoff, would be negatively affected by increases in soil strength. Evidence of compaction recovery between years was found.

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