Late-summer infiltration as affected by cropping and grazing management of winter-wheat pastures

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Abstract: Agricultural practices that incorporate grazed winter wheat and associated summer management are vital to the rural economy of the southern Great Plains. In regions where high intensity, late summer storms can occur, limited information exists about the impact of these practices, including summer fallow and dual-cropping summer fields, on infiltration. This study was designed to determine the effects of two winter wheat management strategies: winter wheat with summer fallow and winter wheat with summer legumes simultaneously with two grazing treatments (grazed and ungrazed) on steady-state infiltration rates. Four pastures were planted in conservation winter wheat (*Triticum aestivum* L.) and grazed over winter when possible from November to March and graze-out from March to May from 1998 to 2002. A dual-cropping management strategy that incorporated summer legumes, Korean Lespedeza (*Lespedeza stipulacea* Maxim) and Soybean (*Glycine max*), was replicated on two of the pastures, while the other two pastures utilized summer fallow. A rainfall simulator calibrated to represent late summer, high intensity (1.67 mm/min) summer storms was used to determine the parameters: time to achieve steady-state conditions (Tss), steady-state infiltration (SSI) rates, and percent of applied rainfall infiltrated at steady-state conditions (%ss). These parameters were shown to be significantly ($P < 0.10$) impacted by the grazing practices in all instances and the management practices associated with winter wheat in some cases. Grazed winter wheat utilizing summer fallow had the lowest infiltration rate with 0.91 mm/min along with the shortest Tss (19 min) and the lowest %ss (56%). Grazed summer legumes and ungrazed summer fallow displayed similar infiltration parameters (SSI = 1.47 and 1.33 mm/min, Tss = 28 and 30 min, %ss = 81% and 81%, respectively) and ungrazed summer legumes had the least impact to the infiltration with a SSI rate of 1.59 mm/min, Tss of 37 min and %ss of 88%. Understanding the mechanism of interaction between late summer storms and summer management practices will lead to formulation of larger scale mitigation strategies to reduce erosion and enhance capture of precipitation and runoff.

Key words: legumes—livestock grazing-steady—state infiltration summer fallow—winter wheat

The southern Great Plains is an important region for both cow/calf and stocker cattle operations. Stocker cattle from farms throughout the southeast United States are shipped to the Great Plains to graze warm and cool season grasses before finishing on grain in feedlots in western Texas, Oklahoma or Kansas (figure 1) (Peel 2003). An important part of this activity involves grazing annual winter wheat from mid-November until graze-out in early-May. Livestock production is economically important to this region where, for example, approximately 1.5 million stocker cattle graze wheat pastures covering 1.2 million ha (2.97 million ac) in Oklahoma alone (Redmon et al. 1995; Krenzer et al. 1996).

Stocker grazing activity, such as trampling, defoliation, defecation and urination, can have detrimental effects on soil properties, including decreased infiltration (Van Haveren 1983; Daniel et al. 2002). Infiltration rates on fescue grasslands in the foothills of Alberta, Canada were found to decline following short-term, intense periods of grazing (Naeth and Chanasyk 1995, 1996). Further, detrimental effects of grazing may become more significant during periods of drought or winter dormancy (Warren et al. 1986). Saleem and Mwendera (1997) demonstrated that heavy grazing significantly reduced water infiltration of ploughed soils which had been exposed to heavy trampling by livestock. However, results from some studies demonstrate that grazing is not as detrimental to soil hydraulic properties as originally thought. In a rainfall simulator study, Beukes and Cowling (2003) found an increase in the steady-state infiltration rate and cumulative infiltration for grazed pastures, probably caused by the fragmentation of soil crusts compared to control sites, but this increase was absent for a second rain event. Wheeler et al. (2002) found that infiltration rates quickly declined in response to grazing, but returned to ungrazed levels within one year, suggesting full hydrologic recovery possibly related to frequent freeze-thaw events and high organic matter in the soils. Hiernaux et al. (1999) ascertained that soil infiltration slightly increased with moderate grazing but decreased at higher stocking rates. Krzic et al. (1999) found that the rate of water infiltration was not affected by long-term grazing and forage seeding in lodgepole pine plantations in British Columbia. In a typic Natraquoll soil in Argentina, Taboada and Lavado (1988) found no severe or long-term damage to soil properties due to livestock grazing.

Changes in infiltration characteristics have also been associated with fallow conditions, but this information is limited. Shaver et al. (2002) examined dry land no-till management in eastern Colorado and demonstrated a loss of infiltration capacity in pastures utilizing fallow practices. To improve infiltration after summer fallow, deep ripping the field before planting fall wheat was shown to be effective (Schillinger and Wilkins 1997). No-till practices conserved more water during fallow periods but did not contribute to a consistent increase of infiltration (Christensen et al. 1994).

It is tempting to increase stocker production by incorporating summer grazing of warm season grasses into winter wheat man-

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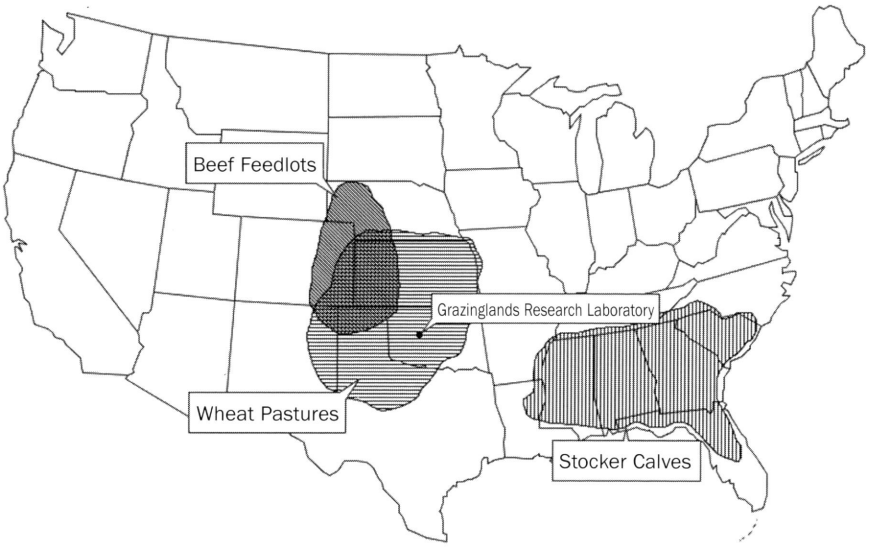
Figure 1
Study site and extent of the winter wheat belt and beef feedlots used for stocker finishing in the United States.



Notes: Stocker calves are born and weaned in the southeastern USA and shipped west. Because of the proximity of feedlots, in which 85% of the nation's beef is finished on, winter wheat grazing plays a major role in the Oklahoma economy and the nation's beef.

agement practices; however, problems may arise. Summer fallow management practices, in which herbicide is used, represent a low-risk, water-conservative strategy commonly used in the southern Great Plains. Precipitation is harvested as infiltration and retained in the soil profile. In the absence of living plants, evapotranspirative processes are greatly reduced and stored soil water is available for wheat planted in the fall. The use of double-cropping with summer legumes is a more water-aggressive management strategy which involves a higher risk. Precipitation, harvested by infiltration and stored as soil water, is not saved but is utilized to grow a second crop. This increases the risk of diminished soil water reserves in the fall, thus impacting winter wheat establishment.

The objective of this project is to examine changes in steady-state infiltration parameters on winter wheat pasture, which utilizes various summer management practices, including summer fallow and double cropping and livestock grazing treatments. The parameters include time to achieve steady-state conditions (Tss), steady-state infiltration (SSI) rate, and percent of applied rainfall infiltrated at steady-state conditions (%ss).

Methods and Materials

Study Site. The research was conducted at the Grazinglands Research Laboratory (GRL) of the USDA Agricultural Research Service near El Reno, Oklahoma (figure 1) within the Red Prairies region in the southern Great Plains of Kansas, Oklahoma and Texas where winter wheat production is prevalent. Annual rainfall between 1971 through 2000 averaged 74 cm (29 in) with a recorded maximum rainfall of 120.7 cm (47.5 in) and a minimum of 60.2 cm (23.7 in). Precipitation records for the previous twenty years show that annual rainfall is seasonally distributed as follows: 10.5% in the winter, 31.6% in the spring, 32.0% in the summer, and 25.5% in the fall. Summer rainfall can be received in short but intense storm events.

Four, 1.6 ha (4 ac) pastures, which are part of several established experimental watersheds constructed in 1976, were used for this study (Daniel 2001). The pastures, with a slope gradient of three to 5%, are situated on the Renfrow-Kirkland soil map unit (fine, mixed, thermic Udertic Paleustoll; mean-particle size distribution—loam: 37.5% sand, 40% silt, and 22.5% clay). Renfrow soils are typically found on crests and side-slopes, and are well drained (Fisher and Swafford 1976). They develop on residuum originating from calcareous shale material. Kirkland soils are found chiefly on crests and are moderately well-drained, formed from the underlying shale parent material. Permeability of all these soils is slow (0.25 mm/min to 0.83 mm/min) (NRCS 1999; Fisher and Swafford 1976).

Initial preparation by moldboard plow and repeated disking for all four pastures was completed in the fall of 1997. All subsequent planting was done utilizing no-till practices (no-till drill of wheat). Beginning in the fall of 1998, a practice of winter grazing and spring graze-out of winter wheat (*Triticum aestivum* L.) was applied to all pastures.

This study incorporates two summer management strategies as part of a livestock production system incorporating grazed winter wheat: summer fallow (SF) and dual-cropping with summer legumes (SL); and two livestock treatments: grazed and ungrazed. The SL used are Korean Lespedeza (*Lespedeza stipulacea* Maxim) and Soybean (*Glycine max*). The two summer management practices, SF and SL, were replicated within the four pastures, with Korean Lespedeza used in the 2000 and 2001 rotation and soybeans in 2002. Both Korean Lespedeza and soybeans have a central tap root which should behave hydrologically similar and should not produce different infiltration characteristics. Two, five by five meter exclosures were established on each pasture to restrict livestock grazing and used as ungrazed control management sites.

The stocker cattle were removed after graze-out in May. On the SF pastures all remaining live vegetation was killed by spraying Glyphosate (1.1 kg/ha). Afterward, the SF pastures had the remaining residue mowed to the uniform height of 15 to 20 cm (6 to 8 in). If needed, spraying was repeated to maintain fallow conditions until late September or early October when wheat was planted.

Pastures utilizing SL had seed broadcasted into the non-fallow pastures in early March. Because stocker cattle were still grazing the pastures, the seed was worked into the soil by hoof action. Similar to the SF management practice, the stockers were allowed to graze until May and then removed. The SL continued to grow until mid-July when stockers were reintroduced onto the pastures. This second grazing period typically lasted from mid-July to mid-September. After the stockers were removed, the fields were prepared for planting for the next cycle of winter wheat.

Grazing Treatment. Stocker calves weighing 230 kg (500 lbs) were typically placed on the pastures during the first week of December if forage supplies were adequate.

Additional stockers were used to increase grazing density in early March and were allowed to graze until May and spring graze-out was completed (table 1). The calves weighed approximately 295 kg (650 lbs) after graze-out. However, if forage was inadequate, grazing was terminated early during the winter, but spring grazing resumed in early March. Spring graze-out stocking density was dictated by available forage (70 to 80% utilization).

Rainfall Simulation. A rainfall simulator was used to determine how management practices and grazing affected infiltration. The simulator was a solenoid-operated, fixed multi-nozzle field unit (Miller 1987) attached to a lightweight, portable A-frame constructed from welded aluminum tubing. To provide uniform spray distribution during a simulation, extendable legs on the A-frame permitted the spray nozzles (30 WSQ; wide angle square spray, 104° spray angle, Spraying Systems Co., Wheaton, Illinois) to be elevated to a height of 3 m above the soil surface. Heavy canvas tarps completely enclosed the unit to minimize wind effects on spray patterns. Three square-spray nozzles, spaced 1 m apart, were mounted to spray downward onto the study plot. The interval of spray time on the plots was controlled by use of a variable-speed electric motor with a cam, which dictated the length of spray time and micro switches which activated the spray nozzles (Miller 1987). Water for the simulations (table 2) was hauled to the site using a water trailer with an 1890 liter (500 gal) capacity.

Prior to each simulation run, a hand-pushed mower was used to cut the vegetation and residue to a uniform height of 5 cm (2 in), and cut residue was then hand removed to minimize the impact on the ground surface. This was done to reduce the impact of varying amounts and heights of vegetation on rainfall delivery and allow the rain to fall on a uniformly-prepared ground surface for better comparisons between plots. Rectangular steel frames (1.5 m × 3 m) with flume attached at downslope end) were set into the soil to a depth of 8 cm (3 in) with long end parallel to the slope. Surface flow collected in the flume was transferred to a large plastic storage container by a bilge pump. A pressure transducer was used to measure the water level in the storage container during a simulation. Measurements were transmitted and recorded in millivolts using a Campbell-Scientific (Logan, Utah) CR-10 data logger interfaced to a laptop computer via RS-232 cable. Millivolt readings were converted to water volumes (l) using a conversion equation calibrated for the equipment. Overall rainfall intensity of each run was calculated using four 13.5 cm (5.3 in) diameter collection containers installed at predetermined positions within the frames and volumes measured after the simulation. The plots were not pre-wetted. Antecedent soil water content were obtained from heat dissipation matric potential soil water sensors (model 229-L, Campbell-Scientific; Reece 1996) associated with the Oklahoma Mesonet site situated on native rangeland at the GRL (table 3).

The rainfall simulator was designed to apply water at a predetermined intensity. This rainfall intensity is based on breakpoint precipitation records collected from rain gages at the GRL at El Reno, Oklahoma, and simulates the intense (range: 1.6 to 2.45 mm/min), short duration (range: 15 to 45 min) storms which occur in the southern Great Plains during late summer. Initial rainfall calibration was determined using 36 rainfall collection containers placed in a four by nine grid within the 1.5 m x 3 m plot frame. Average intensity and spray distribution was determined by thirteen, 15-minute calibration runs. The nozzle had spray pressure of 30 kPa. All three nozzles used a 2.5 second cycle but each nozzle would spray in sequence, spraying for 1.9 seconds and switching off for 0.6 seconds until the begin-

Table 1
Total grazing days for winter wheat and summer legumes of the water resources and erosion watersheds during 1998 through 2002.

		Number of grazing days			
		Fallow		Legume	
Grazing season	Management	Rep 1	Rep 2	Rep 1	Rep 2
Fall 1998 to summer 1999	Winter wheat	135	135	135	135
	Legumes	–	–	34	34
Fall 1999 to summer 2000	Winter wheat	60	60	60	60
	Legumes	–	–	0	0
Fall 2000 to summer 2001	Winter wheat	45	41	49	49
	Legumes	–	–	16	0
Fall 2001 to summer 2002	Winter wheat	42	35	39	42
	Legumes	–	–	21	21

Table 2
Averaged water analysis of water used in rainfall simulator.

	2000		2001		2002	
	Average	Std dev.	Average	Std dev.	Average	Std dev.
pH	8.29	0.13	8.28	0.10	8.71	0.26
Conductivity (mhos/cm)	1264	22	982	53	1209	46
Total dissolved solids (mg/L)	842	14	656	36	810	31

Note: Samples were collected from sample cups in the plots during simulations.

Table 3
Average monthly soil water content (vol. %) for September during 2000, 2001, and 2002 at Fort Reno Mesonet site for depths of 5, 25, 60, and 75 cm.

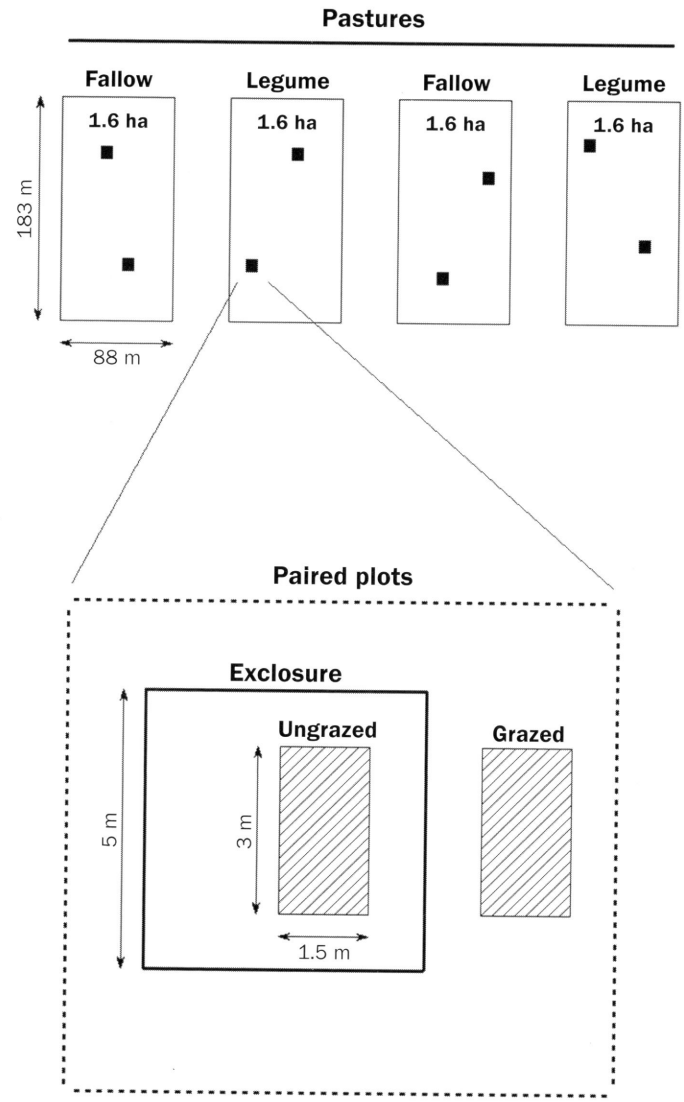
	2000		2001		2002	
Depth (cm)	Average	Std dev.	Average	Std dev.	Average	Std dev.
5	3.82	0.03	2.16	0.30	2.20	0.52
25	3.86	0.03	2.03	0.27	2.04	0.39
60	3.70	0.03	3.67	0.03	2.84	1.00
75	3.67	0.04	3.68	0.01	3.24	0.55

ning of the next cycle (Daniel et al. 2006). An average rainfall intensity of 1.67 mm/min (10.0 cm/hr) (standard deviation 0.08 mm/min) was determined. Rainfall simulations were conducted in September of 2000, 2001 and 2002, after cattle were removed from the SL pastures and the SF pastures had been in fallow for several months, but prior to fall planting. The simulations typically lasted between 35 to 45 minutes, but occasionally a simulation run could last longer. In the field, Tss were ascertained when the runoff flow became constant. SSI rates were calculated by determining the time when Tss were achieved and then averaging the following ten minutes of measurements.

Statistical Treatment. The four pastures were equally divided among the SF and SL management and within each pasture were two exclosures to allow the grazed-ungrazed treatment. The study was done over three years (2000 to 2002) to provide a $2 \times 2 \times 3$ sampling matrix. Each exclosure is associated with a grazed and ungrazed paired plot using a side-by-side positioning (figure 2). Plots were situated two to three meters apart. This side-by-side placement of plots provided a means to compare infiltration rates from grazed and ungrazed treatments for a given management practice. The paired plots provided a strategy to reduce the effects of variability caused by soil type, vegetation cover, and landscape position between the pastures.

Measurements (SSI, Tss, and %ss) underwent a data transformation process (log10(y+1)). Data were analyzed within a replicated (n = 4), completely randomized, split plot design with main effects being agricultural management and grazing treatments in the split plot (Sokal and Rohlf 1995). Replicates used in this analysis were paired plots of individual pastures and the years of the simulations were the block effects. This allowed the effects of time and space to be encompassed within the effects and error terms. A least squares difference (LSD) procedure was used to test for differences in main and interaction effects, using $\alpha = 0.10$ as the level of significance.

Figure 2
Layout of pasture management practice and exclosures on each pasture.



Note: Each exclosure has a grazed and ungrazed paired plot for rainulator simulation.

Results and Discussion

After each simulation was completed and the infiltration data were evaluated, the steady-state parameters were determined. ANOVA results for the experiment are given in tables 4, 5, and 6.

The length of time to reach Tss was found to be significantly different for grazing treatments but not for the management practices (SF vs. SL), the block effects (years), or the treatment and management practice interaction (table 4). Comparison of overall ungrazed and grazed treatments shows that grazing impacts the length of time the soil surface achieves saturated conditions (33 vs. 23 minutes for the ungrazed and grazed, respectively; table 7). The greatest length of time to achieve steady-state conditions of the different strategies was the ungrazed SL (table 7). Conversely, plots with grazed SF practice reached their steady-state infiltration rate at 19 minutes. The remaining two practices achieved steady-state infiltration at 30 minutes for the ungrazed SF and 28 minutes for the grazed SL. Comparison of Tss across years indicate that 2000 and 2001 were 31 and 32 min, respectively, while, 2002 decreased to 22 minutes.

An approach to compare the different management and treatments on infiltration was to determine the %ss. Results of the ANOVA showed a highly significant difference for the grazing treatment for the %ss (table 5). Comparison of the %ss for the overall treatments shows that the ungrazed treatment retained 84% of the applied rainfall as infiltration while 68% of the applied rainfall was infiltrated for the grazed treat-

Table 4
Analysis of variance model response of Tss.

Source	df	Type I SS	MS	F	P	Note
Main plots						
Blocks (years)	2	0.2355	0.11775	2.0786	0.3248	NS
Management (M)	1	0.1915	0.19153	3.3810	0.2073	NS
Main plot error	2	0.1133	0.05665	–	–	
Treatment (T)	1	0.3094	0.30939	32.0428	0.0000	***
(T) * (M)	1	0.0140	0.01402	1.4523	0.2352	NS
Error	40	0.3862	0.00965	–	–	
Total	47	0.8637	0.12339	12.7797	0.0000	***

Notes: R^2 = SSmodel/SStotal = 0.69. Significance levels are indicated from significant (*) to highly significant (****); NS = not significant.

Table 5
Analysis of variance model response of %ss.

Source	df	Type I SS	MS	F	P	Note
Main plots						
Blocks (years)	2	0.0126	0.0063	2.3699	0.2967	NS
Management (M)	1	0.1305	0.1305	49.1456	0.0197	**
Main plot error	2	0.0053	0.0027			
Treatment (T)	1	0.1282	0.1282	15.2408	0.0004	***
(T) * (M)	1	0.0601	0.0601	7.1468	0.0108	**
Error	40	0.3365	0.0084	–	–	
Total	47	0.6733				

Notes: R^2 = SSmodel/SStotal = 0.50. Significance levels are indicated from significant (*) to highly significant (****); NS = not significant.

Table 6
Analysis of variance model response of SSI rates.

Source	df	Type I SS	MS	F	P	Note
Main plots						
Blocks (years)	2	0.0551	0.0275	4.5115	0.1814	NS
Management (M)	1	0.0753	0.0753	12.3388	0.0724	*
Main plot error	2	0.0122	0.0061			
Treatment (T)	1	0.0380	0.0380	8.8580	0.0049	**
(T) * (M)	1	0.0119	0:0119	2.7686	0.1039	NS
Error	40	0.1717	0.0043	–	–	
Total	47	0.3643				

Notes: R^2 = SSmodel/SStotal = 0.53. Significance levels are indicated from significant (*) to highly significant (****); NS = not significant.

ment (table 7). A significant difference level was found for the management practice and for the interaction between the management and grazing treatment (P = 0.0197 and P = 0.0108, respectively). The %ss for the overall management practice indicates that SL management practice had 84% of the rainfall retained as infiltration and the SF practice infiltrated 68% of the applied rainfall (table 7). Further scrutiny of the interaction between the treatments and management practices indicate the plots incorporating the ungrazed SL practice infiltrated 88% of the applied rainfall at steady-state conditions. This was the greatest percent infiltrated rainfall of the combined treatment and management practices (table 7). However, plots utilizing the grazed SF practice infiltrated an averaged 56% of the applied rainfall at steady-state conditions. The remaining two strategies, ungrazed SF and grazed SL infiltrated 81% at steady-state conditions. While overall fallow conditions had a lower %ss than the SL practices, a significant decrease in %ss was found with grazed conditions, suggesting that livestock activity impacts the quantity of rainfall infiltration.

Both the grazing treatment and the management practice are found to significantly impact the SSI rates. However, no significance was found between the management and grazing interactions (table 6). The overall impact of livestock grazing treatment on both management practices suggests an 18% reduction SSI between the ungrazed and grazed treatments (1.46 vs. 1.19 mm/min, respectively). The summer management practices impact on SSI show that a 26% reduction in between the SL and SF (1.52 vs. 1.12 mm/min, respectively). Even though the SSI rate between the treatment and management interactions was not significant ($P > 0.1$), it is considered close enough to discuss the results ($P = 0.1039$). Of the agricultural practices, the ungrazed SL had the highest averaged steady-state infiltration rate (1.59 mm/min) compared to the remaining treatments (table 7). Grazed SL and ungrazed SF treatment combinations followed with the second and third highest SSI (1.47 and 1.33 mm/min, respectively). Grazed SF generated the lowest values of the study (0.91 mm/min). Averaged steady-state infiltration rate for 2000 (1.59 mm/min) was significantly higher than the two other years, respectively (2001, 1.17 mm/min; 2002, 1.21 mm/min). The reason for this difference is suspected to be caused by continued settling and compaction after the pastures were deep moldboard plowed in 1997. This increased settling would lead to decrease infiltration.

Two forage legumes were used in this experiment: Korean Lespedeza and soybeans. These pastures have multi-users and the summer forage was changed to soybeans after two years to fulfill other research obligations. Both of these forage legumes have a similar tap root system and are believed to cause similar soil hydrological behavior. Using a means comparison test (LSD), no significant difference between the means of infiltration rates for the two forage legumes (SSI Lespedeza = 1.38 mm/min and SSI soy bean = 1.21 mm/min) was found, thus supporting the assumption that both the forage legumes caused the soil to behave hydrologically similar.

Table 7
Averaged values for the measured parameters SSI, Tss, and %ss.

Agricultural practice	Treatment	SSI (mm/min)	Tss (min)	%ss (percent)
Both practices	Ungrazed	1.46	33a	84a
	Grazed	1.19	23b	68b
SL	Both treatments	1.52a	32	84a
SF	Both treatments	1.12b	24	68b
SL	Ungrazed	1.59	37	88a
	Grazed	1.47	28	81a
SF	Ungrazed	1.33	30	81a
	Grazed	0.91	19	56b

Note: The "a" and "b" indicate comparison between LSD means.

In general terms within a given crop-management system, higher infiltration rates were found for the ungrazed treatments compared to the grazed treatment. The ungrazed SL had higher infiltration rates than the grazed SL, and ungrazed SF had a higher infiltration rate than the grazed SF. Earlier compaction research show that compaction levels decreased over winter (2.638 MPa compared to 1.991 MPa– a 25% reduction) probably due to increased precipitation and decreased evapotranspiration (Daniel and Phillips 2000). Based on these findings, the differing infiltration rates are believed to be temporary. Other researchers found that changes in infiltration with crop management and grazing practices are a temporary phenomenon (Wheeler et al. 2002; Beukes and Cowling 2003; Krzic et al. 1999; and Taboada and Lavado 1988).

Comparison of the %ss parameters between the management practices and treatment suggests that a lower %ss indicate a possible greater impact from soil sealing or crusting. Conversely, a greater %ss, as found with the legume forage, suggests less impact from soil sealing and crusting. Literature discussions where infiltration and legumes have been studied show that decaying plant roots can serve as preferential flow paths. Alfalfa, another plant with deep tap roots researched in leaching columns at three stages of root decay, was found to have greater movement of water from preferential flow occurring in columns with roots than without roots (Zins et al. 1991). Mitchell et al. (1995) examined two crops with sharply contrasting root systems, alfalfa and wheat, and found tap roots in alfalfa produced stable macropores while wheat with its fine, fibrous roots, produced no such macropores. Likewise, Meek et al. (1990) found that cotton used in a no-till rotation produced high infiltration rates probably as preferential flow through macropores. Based on literature findings and observations found in this study, the grazing treatment significantly impacts the measured infiltration parameters. The presence of the SL apparently decreases the impact of surface sealing and promotes water movement as infiltration. At the time of the rainfall simulations the vegetation was dead, but the remaining stalks and roots may provide conduits for preferential flow through the soil surface. Because minimal till/no-till practices were used for this project, plowing did not destroy the existing root system, and the root structures for both wheat and legumes are still undisturbed. The management incorporating SL (grazed and ungrazed) had a greater infiltration rate than the SF strategy (table 7) because of the probable combined effects of wheat and legume roots and residue.

In the southern Great Plains region, the SF management practice is a conventional water conservation technique. Loss of soil water by evapotranspiration is restricted by eliminating all live vegetation. Accumulated soil water collected from spring and early summer rains is stored over the summer and later harvested by wheat during fall (Thomas et al. 1995; Unger, 1994). However, this practice is not as effective in promoting infiltration to supplement soil water reserves (Pannkuk et al. 1997), particularly when winter and spring grazing is included. Water is collected before a soil crust can form. During the summer, without growing vegetation and a soil crust sealing the ground surface, soil water is not lost to evapotranspiration. However, while the soil crust restricts evapotranspiration, it also restricts infiltration from summer storms and rainfall is lost as runoff (Christensen et al. 1994). Planting a summer crop, such as legumes, is considered an aggressive water-use practice, where soil water is being harvested as a warm season grass rather than allowed to accumulate for fall planting. Badaruddin and Meyer (1989) examined the water use efficiency (WUE), and soil water depletion pattern of four grain legumes and three forage legumes in the northern Great Plains. They found that cumulative water depletion during June to September by forage legumes was found to be 63 mm greater than a fallow check. This was associated with their longer growing season and higher dry matter production.

The ungrazed winter wheat-summer forage legumes management indicates that greater infiltration is occurring and late summer rain has a greater chance of being captured as infiltration, while fallow is effective at conserving water already present in the soil profile. If a rancher or farmer had prior knowledge of the likelihood of rain going into a summer, this information could used to an economic advantage. If a dry summer is forecasted, then a fallow management practice would be the best choice because soil water will be needed for fall wheat planting. If a wetter summer is expected, then a dual cropping management could be successful because summer rains could infiltrate easier and replace the soil water used by the summer crop. To promote infiltration, any management practice to break up the surface crust or rough up the ground surface to form micro-depressions, such as chiseling or disking can promote infiltration. If a cooler summer with occasional rainfall is expected, then a dual-cropping with SL may be appropriate and successful. A surface crust may not be as developed and the deeper root system will provide increased infiltration.

Summary and Conclusions

Grazing treatments and summer management practices associated with no-till are found to influence late summer infiltration rates. Results indicate that the grazing treatment has the greatest impact on steady-state infiltration rates, but SF conditions also influence infiltration. Summer fallow, a management practice typically used in the Southern Great Plains, is documented as effective at retaining water already in the soil. Due to decreased infiltration rates associated with the fallow practice within grazed winter wheat pastures, it is not likely that much rainfall will be captured through infiltration and supplementing stored soil water.

Summer legumes, whether Korean

Lespedeza or soybeans, with their deeper tap roots, may increase infiltration rates. But these methods can only be successful if there is adequate precipitation to offset the use of soil water by the legumes.

The addition of SL to increase beef production is a high risk management practice using soil water which may be needed for fall planting. Currently research is underway to provide farmers with climate information so that choices of management practice can be made at a lower economic risk. It is advantageous to capture as much late summer rainfall as possible. To increase the chance of capturing rainfall from summer storms, crop residue with the stalks and root structure left intact can possibly increase infiltration as preferential flow, but this may not be enough to do an effective job. Breaking up the soil surface by disking or chiseling after graze-out may increase surface roughness of a field and provide micro topographic depressions in which to capture rainfall and promote infiltration during the first rain event following tillage.

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