Improvement of Panspot (Solonetzic) Range Sites by Contour Furrowing

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Highlight: *We studied the effects of 3-, 7-, and 10-year-old contour furrowing on some physical and chemical soil properties of panspot range sites in southeastern Montana. Changes in soil bulk density, sodium-adsorption-ratio (SAR), and salinity (EC) on the contour-furrowed areas were generally small, but a definite ameliorating trend was established. Contour furrowing increased infiltration rates 0.25 to 3.11 cm/hr and increased forage yields 498 to 770 kg/ha. Reduced SAR and EC on contour furrowed areas were attributed to increased infiltration.*

Contour furrowing, a mechanical range renovation treatment, has been used successfully to increase range herbage production (Branson et al., 1962; and Wein and West, 1971). Branson et al. (1966) worked with seven different mechanical treatments and found that contour furrowing and broadbase furrowing increased herbage production more than the other methods. Hubbard and Smoliak (1953) found that, after 13 years, contour dikes were still beneficial in increasing herbage yields.

Information on soil physical and chemical properties from contour-furrowed areas is limited. Wight and Siddoway (1972) found that contour furrowing significantly increased soil water during some portions of the growing season. Branson et al. (1966) observed that average soil water storage was nearly 8% greater in contour-furrowed soils than in unfurrowed soils and reported leaching of salts from upper to lower depths in a 0- to 60-cm soil profile on contour-furrowed sites.

Contour furrowing has been used extensively by the Bureau of Land Management in eastern Montana and elsewhere to reduce runoff and erosion and to increase herbage production. Except for the work of Branson et al. (1966), little information has been reported on the effects of this land treatment with time on edaphic factors. The objectives of our study were to determine the effects of contour furrowing on selected physical

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Table 1. Soil properties of the 0- to 30-cm soil profile of the check treatment of three experimental sites in September 1970.

Sites	Depths (cm)	Texture	Bulk density (g/cm)	pH	Electrical conductivity (mmhos/cm)	Cations (meq/1) Na	Ca	Mg	K	Anions (meq/1) SO_4	HCO_3	CO_3	Cl
1960	0–10	Silt loam	1.29	6.2	2.2	23	7	5	<1	30	4	<1	<1
	10–20	Clay loam	1.46	7.3	3.0	32	6	6	<1	35	7	<1	<1
	20–30	Clay	1.40	7.7	5.6	53	14	15	<1	74	7	<1	<1
1963	0–10	Clay loam	1.33	7.6	2.0	23	6	3	<1	23	6	<1	<1
	10–20	Clay	1.32	7.8	4.7	44	10	9	<1	55	6	<1	<1
	20–30	Clay	1.31	7.8	6.0	59	13	17	<1	84	4	<1	<1
1967	0–10	Loam	1.32	7.0	2.7	28	8	6	<1	32	9	<1	<1
	10–20	Clay	1.31	7.7	5.1	53	9	11	<1	65	8	<1	<1
	20–30	Clay	1.32	7.8	6.6	69	11	17	<1	93	5	<1	<1

and chemical soil properties of panspot range sites in southeastern Montana.

Site Description and Methods

The study was located on a "frail land" research area approximately 24 km south of Ekalaka, Mont. Frail lands are defined by the Bureau of Land Management as those rangelands in the Pierre Shale Plains and Badlands Land Resource Area comprised of eroded saline-sodic soils with associated panspots or scabspots. Soil properties of the study sites are illustrated in Table 1. Water infiltrates very slowly into these sparsely vegetated soils. Dominant vegetation is thickspike wheatgrass (*Agropyron dasystachyum*), western wheatgrass (*Agropyron smithii*), sandberg bluegrass (*Poa secunda*), blue grama (*Bouteloua gracilis*), clubmoss (*Selaginella densa*), big sagebrush (*Artemisia tridentata*), and pricklypear cactus (*Opuntia* sp.). Crested wheatgrass (*Agropyron cristatum*) was a dominant species on the 1960 site.

Climate is typically continental in this semiarid area of the Northern Plains. Annual precipitation averages about 25 cm, with about 80% falling from April through September. In some years, a large percent of the annual precipitation falls in a few intense storms. The average frost-free season is 127 days.

Sites selected in 1970 for study had been contour furrowed 3, 7, and 10 years prior to sampling. The sites are identified in this study according to the year treatment was applied; i.e., 1960, 1963, and 1967.

On all areas selected for sampling, contour furrowing was applied with a model B contour furrowing machine developed by the Forest Service, U. S. Department of Agriculture, Arcadia, California. Two offset disk units, 1.5 meters apart, formed two furrows approximately 50 cm wide and 15 to 25 cm deep simultaneously (Fig. 1). The furrow bottoms represent 30 to 40% of the contour-furrowed areas. Rippers ahead of the disks fractured the soil to a depth of 25 to 40 cm. Check dams were formed in the furrows about every 5 meters by a device on the machine.

Double-ring cylinder infiltrometers (flood type) were used to determine water intake of soils (Haise et al., 1956). Water level measurements were taken 1, 3, 8, 18, 33, 53, 83, 128, and 188 minutes after water was initially applied to the soil in the inner ring.

Within each site, infiltration measurements were made on three separate blocks. Each block represented an area with minimum variation in microtopography and vegetational cover. Within each block, infiltration measurements were replicated three times within the furrows, on adjacent ridges, and on bordering nonfurrowed areas. The three within block subsamples were averaged prior to statistical analysis. Data from each site were analyzed separately, utilizing a randomized complete block design with three blocks and three treatments (furrow, ridge, and check).

Soil samples were taken by 10-cm increments to a depth of 60 cm adjacent to each infiltration run. The three subsamples from each block were composited prior to physical and chemical analyses. Textures (hydrometer method) and bulk densities (on cores) were determined for all composited soil samples; pH was measured in the saturated soil paste; and Ca, Mg, Na, K, CO_3, HCO_3, Cl, and electrical conductivities, EC (expressed as mmhos/cm at 25°C), were determined from saturated paste extracts. Sulfate was calculated by difference: SO_4 = total cations - (HCO_3 + CO_3 + Cl). The sodium-adsorption-ratio

$$(SAR) = Na/\sqrt{Ca + Mg/2},$$

with ionic concentrations expressed in milliequivalents per liter (meq/1), was used to characterize changes in sodium hazard. Electrical conductivity (EC) was used to characterize soil salinity and soluble salt movement within the 0- to 60-cm soil profile. Methods of chemical and physical analyses used were those outlined by U.S. Salinity Laboratory Staff (1954) and by Black et al. (1965 a, b).

Soil data from each site were statisti-

Fig. 1. *Contour-furrowed range site.*

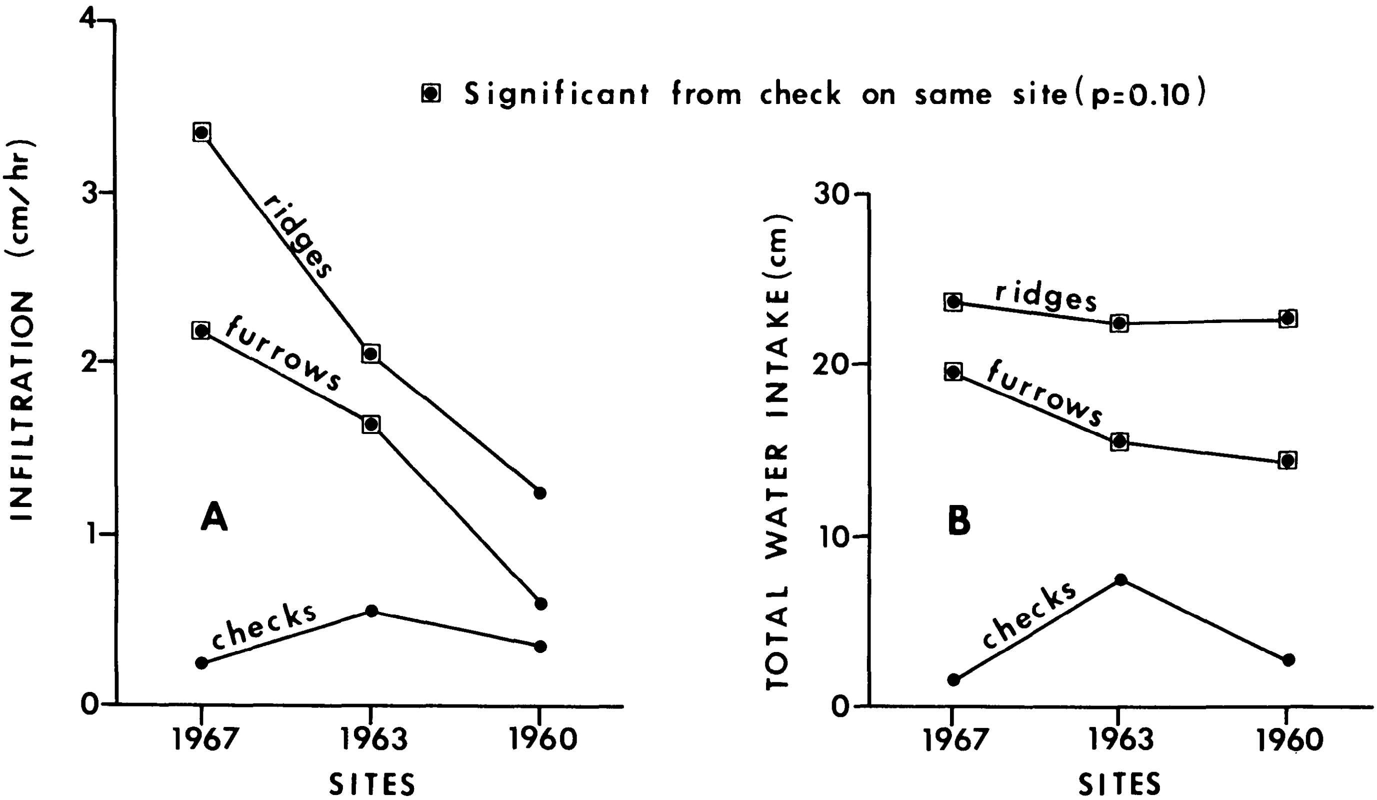

Fig. 2. *Third-hour infiltration rates (A) and total water intake (B) for ridges, furrows, and checks at the three study sites. Measurements were made, 3, 7, and 10 years after treatments for the 1967, 1963, and 1960 sites, respectively.*

cally analyzed using a split plot design with furrow, ridge, and check treatments as main plots and soil depth increments as nonrandom subplots. The 10% significance level was used in all analyses of variance.

Vegetation was sampled in 1971 by clipping all growth from four to eight 0.5- by 2-m quadrats. Samples were ovendried at 70°C before weighing and are expressed on this basis. All species except big sagebrush, pricklypear cactus, and clubmoss were sampled.

Results and Discussion

Infiltration rates and total water intake measurements on contour-furrowed areas (both ridges and furrows) were higher than those on adjacent check areas on all three sites (Fig. 2). According to observations of newly furrowed areas (Fig. 1), fracturing and loosening of the soil by contour furrowing should increase infiltration rates. However, the physical disturbance effect should decrease with time as settling, erosion, and vegetation exert their influence.

There were few measurable differences in bulk densities among soil samples from furrows, ridges, and check areas on all sites. However, on the 1967 site, bulk densities in the 0- to 10-cm depth in the ridges and under the furrows were 1.07 and 1.08 g/cm^3 and were significantly less than the 1.32 g/cm^3 found in the 0- to 10- and 20- to 30-cm depths in the check areas. Since the 1967 site was the most recently furrowed (3 years old), the physical disturbance effect from contour furrowing is probably still present and will partly explain the lower bulk densities. Highest infiltration rates (Fig. 2) were found on the 1967 site and were associated with low bulk densities in addition to chemical differences discussed later.

Rauzi and Kuhlman (1961) and Branson et al. (1962) mention the influence of soil cracking on infiltration on similar soils. Although cracks in these clay soils become evident during dry periods, larger and more numerous soil cracks on contour-furrowed areas appear to be the result of differential soil water usage by the increase in forage production on the ridges. We found the highest initial infiltration rates on contour-furrowed areas where cracking was most prevalent.

Contour furrowing did not significantly affect pH and water soluble K, SO_4 HCO_3 Cl, and CO_3 in the 0- to 60-cm soil profile (data not presented), but it did change the proportion of Ca, Mg, and Na in some of the 10-cm soil increments as is indicated by changes in sodium-adsorption-ratios. Sodium-adsorption-ratios from soil samples indicated contour furrowing reduced the sodium hazard in the upper soil depths (Table 2). Sodium-adsorption-ratios in the furrows in the 0- to 20-cm depth on the 1960 site, in the 0- to 10-cm depth on the 1963 site, and in the 0- to 40-cm depths on the 1967 site were significantly less than the 20- to 40-, 20- to 30-, and 20- to 60-cm depths in the ridges and check on the respective sites. Although not always significant, sodium-adsorption-ratios in the upper depths in the furrows and ridges on all sites were generally lower than sodium-adsorption-ratios in the upper depths in adjacent check areas. Reduction in sodium hazard was no doubt due to increased infiltration on contour-furrowed areas. Even though the physical effects of contour furrowing decreased with time, improved soil physical conditions apparently resulted from the reduction of sodium, thereby creating favorable infiltration characteristics.

Although soil salinity in the upper soil depths was not reduced in comparison to the check on any site, contour furrowing did affect movement of salts in the furrows (Table 2). Immediately after furrowing, soluble salts in the 0- to 10-cm depth in the furrows should have been about the same as the soluble salts in the 20- to 30-cm depth for the check areas. Results of our study show that salinity in the 0- to 10-cm depth in the furrows on all sites was significantly less than the salts in the 20- to 30-cm depth on the check areas. Leaching of salts from the upper soil depths in the furrows is due to increased infiltration from water retained in the furrows.

According to White (1969), in reference to panspot range sites in South Dakota, a treatment which throws soil materials on the surface of adjacent undisturbed soil may destroy short grasses and trap water to stimulate growth of species such as wheatgrasses. Although we do not show the detailed data in our study, contour furrowing created these conditions and significantly increased herbage production (mainly thickspike and western wheatgrass) by 171 to 326% over corresponding check areas on all sites. Herbage production in 1971 on contour-furrowed areas was 1,072 kg/ha on the 1967 site, 789 kg/ha on the 1963 site, and 1,006 kg/ha on the 1960 site, as compared to 357, 291, and 236 kg/ha on the respective check areas. The herbage data show that contour furrowing increased herbage production 11 years after treatment.

Changes in physical and chemical characteristics of soil on contour-furrowed areas were small, but definite ameliorating trends were established. Permanent effects of contour furrowing on soil chemical and physical properties are not known at this time. However, results from this study show that contour furrowing on a panspot (Solonetzic) range site improved infiltration, reduced the sodium hazard, and increased herbage production for at least 10 years.

Table 2. Mean sodium-adsorption-ratios (SAR) and salinity values (mmhos/cm) for checks, furrows, and ridges in September, 1970.

	Depth interval from soil surface (cm)		SAR			EC		
Site	Check & Ridge	Furrow	Check	Furrow	Ridge	Check	Furrow	Ridge
1960	0–10		9.9		7.5	2.2		1.2
	10–20		14.1		10.9a	3.0		3.2
	20–30	0–10	14.0	6.4ab	13.3	5.6	1.5a	4.4
	30–40	10–20	15.3	7.3ab	15.2	5.8	2.9a	6.0
	40–50	20–30	14.6	12.9	17.2	5.7	5.7	6.6
	50–60	30–40	16.9	16.9	17.3	6.4	6.8	6.4
1963	0–10		10.5		4.5a	2.0		2.3
	10–20		15.0		8.0a	4.7		3.2a
	20–30	0–10	15.1	6.4a	14.2	6.0	3.8ab	6.2
	30–40	10–20	17.1	17.3	19.5	6.5	7.7ab	8.5a
	40–50	20–30	20.0	22.6b	21.8	6.9	9.5ab	9.0a
	50–60	30–40	20.5	23.9ab	22.7	7.8	9.8ab	8.1
1967	0–10		11.2		7.8	2.7		3.4
	10–20		17.3		9.7a	5.1		3.4a
	20–30	0–10	18.3	6.7ab	14.7a	6.6	2.8a	4.7a
	30–40	10–20	18.2	8.8ab	17.0	6.5	4.1a	6.2
	40–50	20–30	19.0	13.6ab	19.9	6.1	5.4b	7.0
	50–60	30–40	20.0	16.2a	20.0	7.2	6.5	7.2

[a] Indicates ridge and/or furrow significantly different ($P = .10$) from check at original depths before contour furrowing.
[b] Indicates furrow significantly different ($P = .10$) from check at same depths from soil surface.

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