RANGE TREATMENT EFFECTS ON INFILTRATION RATES

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ABSTRACT

Mechanical treatments of depleted, brush-infested arid rangeland is important in a rehabilitation program. The effects of rootplowing and seeding treatments were examined using a sprinkling infiltrometer, and infiltration and runoff data were compared for creosotebush, bare soil, a 1972 rootplowed and seeded treatment, and a 1976 rootplowed and seeded treatment. There were no differences among treatments in time required for runoff to begin. The plots infested with creosotebush had the greatest infiltration and the bare soil plots had the least. Under dry antecedent soil water conditions, rangeland rootplowed and seeded in 1972 had greater infiltration than that treated in 1976.

INTRODUCTION

Rainfall is inadequate and its distribution too uncertain to maintain vegetation that protects the soil in the arid and semiarid rangelands in the southwestern United States. Attempts have been made to convert rangeland in desert shrubs, which are often not suited for livestock grazing, to more desirable plant species (Tromble, 1976). Knowledge of the effects of rangeland treatments and factors on water yield is important in establishing new plant species and managing these arid rangelands for optimum productivity. Rowe and Reimann (1961) listed soil depth and water storage capacity, rainfall amount and distribution, and the vegetation type before and after site conversion as important parameters influencing soil water. Other parameters affecting soil water are storm intensity, watershed size, and soil surface characteristics.

The objective of this study was to evaluate the effects from two years of rootplowing and seeding treatments on infiltration and runoff.

Sparse vegetation on arid and semiarid rangelands means that the soil surface conditions generally determine infiltration rates (Duley and Kelly 1939; Horton 1940: Dixon 1966; and Kincaid and Williams 1966). Rauzi and Fly (1968) showed that the soil structure of the uppermost horizon is highly correlated with water intake during the second 30-minute period of 1-hour infiltration tests. Texture of the second horizon was second in importance, and the nature of the boundary between the first and second horizons was third.

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Kincaid et al. (1964) reported a strong correlation between infiltration and plant cover in southern Arizona. Most of the variation caused by plant cover is associated with differences in crown spread of shrubs and half shrubs. The community was dominated by whitehorn (*Acacia constricta* var. *vernicosa*), creosotebush (*Larrea divaricata*), and tarbush (*Flourensia cernua*). Rauzi and Fly (1968) reported that the amount of vegetation, both old and new, generally had the greatest correlation with water intake on midcontinental rangelands. This correlation between plant cover and infiltration on midcontinental rangelands, as compared with arid rangelands where the soil surface is important in controlling infiltration, may indicate a possible threshold value where vegetation cover influences infiltration more than soil surface conditions. Schreiber and Kincaid (1967) reported that average runoff for any location-year increased as precipitation volume increased, decreased as vegetation crown cover increased, and increased as antecedent soil water increased. Conversion of arid and semiarid shrub-covered rangelands to more desirable forage species can be facilitated by mechanical treatments. Rootplowing to kill the undesirable brush species and then seeding forage species is an important method used in the southwestern United States to improve rangeland. This method disturbs the soil surface, prepares a seedbed, and can enhance soil water storage. Kincaid and Williams (1966), after brush clearing, pitting, and grass-seeding runoff plots, found little correlation between the mechanical treatments and surface runoff. However, runoff significantly decreased on these plots as the crown cover of vegetation increased.

On runoff plots in southeastern Arizona, crown cover and erosion pavement were the two most significant factors in runoff reduction on Rillito-Karro gravelly loam soil (Tromble 1976). Vegetation cover on the control plots (mostly creosotebush) was 41.7 percent, whereas for the rootplowed and seeded treatment, it was 17.5 percent.

Branson et al. (1966) studied seven different mechanical treatments. The two that were most effective for increasing forage were: a) contour furrowing at 0.9- and 1.5-m intervals, and b) broadbase furrowing consisting of low dikes about 0.5 m. high. In one study, contour furrowing lasted about 15 years in southern Arizona, and grass production was 2.5 times greater on the treated then on untreated adjacent areas 10 years after treatment (Brown and Everson 1952). However, treatment effects on runoff were not determined.

On the Rio Puerco drainage in New Mexico, Dortignac and Hickey (1963) reported that surface runoff was reduced 97 and 83 percent the first and third years after treatment, respectively, on an area that was ripped and seeded to grass and browse species. Erosion was also reduced after the ripping treatment, 86 percent the first year and 30 percent the third year.

Simanton et al. (1978) reported that ripping decreased runoff tenfold with little change in vegetation composition or percent crown cover on a 224-ha watershed in southern Arizona. On a 24-ha watershed rootplowing and seeding significantly reduced runoff but this reduction was not observed until 4 years after treatment. Sediment yields were reduced 60 percent after treatment.

METHODOLOGY

Infiltration rates using a sprinkling infiltrometer (Purdue type) were determined in the summer of 1976 on a Tencee soil (Typic Paleorthid) in southern New Mexico. These soils are shallow and range from poorly drained to well drained. They are in the hydrologic group D and have a final infiltration rate of 0.0 to 0.13 cm/hr (Musgrave 1955). The slope of the landscape was 3 to 5 percent in a westerly direction and plots were located for uniformity in slope and soils. Two sites were selected for infiltrometer tests on different age rootplow treatments. One site was rootplowed and seeded in 1972 and the other in 1976. These sites were originally dominated by creosotebush. On a nearby site, infiltration tests were made so that comparisons could be made of both creosotebush cover and bare soil along with the two treatments.

Annual precipitation is about 254 mm. Approximately 40 percent of the precipitation comes from winter frontal storms and 60 percent from short duration, high intensity convective summer storms.

Effects of antecedent soil water (the wet run) were determined on 1-m^2 plots by repeating the infiltration test 24 hours after the initial test (the dry run). The four treatments were defined as follows: a) creosotebush control (T-C), b) bare soil control (T-B), c) rootplow and seed 1972 (RP-2), and d) rootplow and seed 1976 (RP-6). The T-C infiltrometer test was run over the creosotebush canopy and the T-B infiltrometer test was run over the interspace (bare soil, control) between the creosotebush. Each treatment was replicated four times. Simulated rainfall was applied at the rate of 17.8 cm/hr. Runoff was collected and monitored continuously using a water stage recorder mounted on a volumetric tank. Infiltration rates were determined by subtracting the measured runoff from the application rate of the rainfall simulator. They were determined after 10 and 60 min.

Forage production was determined by clipping and oven drying the plant material from 1-m^2 plots randomly located on the two treatment areas. Crown cover was determined from 25 point measurements taken on each infiltration plot.

RESULTS AND DISCUSSION

An analysis of variance indicated no significant difference between treatments in the time from the start of simulated rainfall to the start of runoff. Average time to beginning of runoff for all treatments was 3 min. No significant differences among treatments were indicated in infiltration rates after 10 min using an F-test. However, significant differences in infiltration rates were observed after 60 min.

A Duncan's multiple range test to test for significant differences in infiltration among treatment means after 60 min showed the T-C dry treatment had a significantly higher infiltration rate than any of the other treatments (Table 1). No significant differences among means were shown for the T-B wet, RP-2 wet, RP-6 dry, and the RP-6 wet treatments. Treatments T-B dry, RP-2 dry, and T-C wet were not significantly

different from each other, but had significantly greater infiltration than treatments T-B wet, RP-2 wet, and RP-6 dry.

Table 1. Differences between treatment means for infiltration rates (cm/hr) after 60 minutes.

	Treatment**							
	T-B wet	RP-2 wet	RP-6 dry	RP-6 wet	T-B dry	RP-2 dry	T-C wet	T-C dry
means	1.39*	1.80	2.25	3.39	4.68	5.51	6.72	9.41

*Value underscored by the same line indicate no significant difference in treatment means using a Duncan's multiple range test.

**T-C = control, creosotebush; T-B = control, bare soil, RP-2 = rootplowed and seeded, 1972; RP-6 = rootplowed and seeded, 1976.

Forage production on the RP-2 treatment was 897 kg/ha compared to practically no production on the recently treated RP-6 treatment. This difference in vegetation cover apparently did not influence infiltration rates between the RP-2 and the RP-6 treatments since there was no significant difference between the RP-2 wet, RP-6 dry, and the RP-6 wet treatments. Infiltration rates for the RP-2 and RP-6 treatments may have been affected more by differences in the antecedent soil water content than by vegetation cover. The greater amounts of vegetation produced on the RP-2 treatment should have decreased the available soil water to less than that on the RP-6 treatment. This would be reflected by the higher initial infiltration of the RP-6 plots.

The creosotebush (wet) plots had an infiltration rate 4.8 times as great as the bare soil (wet) plots. Infiltration after 60 min was 3.7 and 2.0 times greater for the T-C wet treatment than for the RP-2 wet and the RP-6 wet treatments, respectively. Even though the rootplowing and seeding treatments roughened the soil surface as compared with the control, this roughness was apparently not adequate to affect the protection afforded by the cover of the creosotebush canopy.

An infiltrometer test (Tromble et al. 1974) was run on Cave soils (Typic Paleorthids) (Gelderman, 1970) in southeastern Arizona. Comparison of the Cave soils and the Tencee soils (Neher and Bailey, 1976) in this study illustrate several interesting points. Both soils are in the hydrologic soils group D, and have a caliche layer about 38 to 50 cm below the soil surface. They are classified as a gravelly loam soil and are typical of Southwestern rangeland soils infested with creosotebush. These two soils exhibited similar hydrologic characteristics when tested using a sprinkling infiltrometer. Comparisons of the infiltration data from these two soils showed the following: a) bare soil plots had the least infiltration and the most runoff, b) plots infested with creosotebush had the greatest infiltration and the least runoff, and c) grass plots had greater infiltration than bare soil plots but less infiltration than creosotebush plots.

Further evaluation of the data presented by Tromble et al. (1974) for the Cave soils shows that infiltration at the end of 60 min was nearly as great on plots with 30 percent crown cover as on plots with 70 percent crown cover (Fig. 1). For the 20 and 30 min tests an increase in crown cover percentage influenced infiltration only slightly. This indicated that some factor must have been influencing infiltration more than crown cover during the initial wetting phase.

The consistency in infiltration under varying crown cover percentage for time periods less than 1 hour for soils associated with creosotebush may be explained by water repellancy. DeBano (1968) reported that, in the chaparral brushlands of California, the soils exhibited water repellant characteristics. For water repellant soils, the uptake of water is slower at the beginning of infiltration than after water has been entering the soils for a period of time (Letey et al. 1962; Hillel 1967; Meeuwig 1971). Also, faster infiltration rates have been reported in moist soils than in similar dry soils (Gilmour 1968). Initially, the resistance to wetting may be large, but infiltration rates increase as resistance decreases. This change in wettability with time may involve two factors (DeBano 1975): a) the substances that are responsible for water repellancy may be slightly water soluble and dissolve slowly, in turn increasing wettability of the soil, and b) the hydrophobic material on the soil particle surface may not be continuous (Bond, 1964) and some water may be absorbed on the wettable sites. The initial wettability

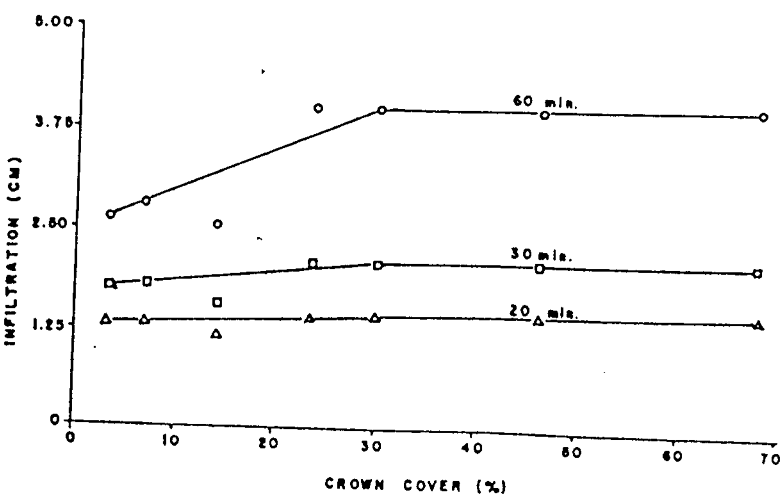

Fig. 1. Infiltration vs. crown cover after specified time periods for Cave soils (Tromble et al. 1974).

of soils may be of particular importance in the southwestern United States since total runoff-producing rainfall from summer convective storms is generally less than 1 hour in duration (Osborn et al. 1979).

SUMMARY

Mechanical treatment is important in converting rangeland infested with creosotebush to grass. The treatment and use of rangelands in a manner which leaves them capable of infiltrating a maximum amount of precipitation is a prime consideration to the production of forage and the control of runoff and erosion. Comparisons of infiltration-runoff data from a sprinkling infiltrometer were made for native desert vegetation, bare soil, a 1972 rootplowed and seeded treatment, and a 1976 rootplowed and seeded treatment. There were no differences in time to beginning of runoff among treatments. The native shrub plots had the greatest infiltration rates whereas the bare soil plots had the least infiltration after 1 hour. Rangeland rootplowed and seeded in 1972 had greater infiltration than rangeland treated in 1976.

Because of the increased infiltration indicated by these data there would be a hydrologic advantage for creosotebush covered rangeland for up to 4 years following the treatment. Protection is provided by the rootplow and seeding treatment, especially after some time, as indicated by the increased infiltration on the RP-2 treatment as compared with the RP-6 treatment.

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LAND IMPRINTING FOR BETTER WATERSHED MANAGEMENT[a]

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ABSTRACT

We are developing a unique conservation plow for imprinting land surfaces with complex geometric patterns designed to increase and stabilize land productivity through improved control over rainwater infiltration. Worldwide overgrazing of pasture and rangelands and excessive tillage of croplands decrease rainwater infiltration and increase runoff and erosion, thereby triggering a vicious circle of land deterioration or desertification. To reverse this cycle of increasing land barrenness and aridity, the land imprinter forms rainwater-irrigated seedbeds and seedling cradles which help to ensure successful crop seed germination, seedling growth, and vegetative cover establishment. Thus, the temporary control of infiltration, runoff, and erosion provided by the land imprinter favors revegetation and relatively permanent biological control of these processes.

INTRODUCTION

Vast barren land areas, particularly in semiarid and arid regions of the world, need to be revegetated for protection against erosion and for efficient use of soil and water resources in the production of food, feed, and fiber. Historically, cropland tillage implements have been modified and redesigned in an attempt to revegetate such land areas. The resulting implements are referred to in the literature as the eccentric disc pitters (14), brushland disc plows (12), root plows (1), moldboard plows (10), land rippers (8), land furrowers (11), and brush cutters and shredders.

The seedbed produced by any one of the preceding implements is usually not good enough to insure vegetative establishment in arid and semiarid regions. These implements generally require a large amount of energy to perform each tillage function. Tillage functions are often too few in number, inappropriate in kind or intensity, and conflicting in purpose. Consequently, both the longevity and the initial suitability of the seedbed is diminished. Even when these implements are used in

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