A Comparative Study of Soils of Selected Creosotebush Sites in Southern New Mexico

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Communities in which creosotebush (*Larrea divaricata* Cav.) is dominant cover large areas of rangeland in the Southwest. The general aspect of most of these communities is that of an open stand of shrubs with little or no soil-protecting or forage-yielding ground cover. Their prevalence and persistence suggest that they represent the full potential of their environments for supporting vegetative cover. With reference to many of these communities in southeastern Arizona, New Mexico and Texas, however, several workers have indicated that this is not the case, but that a former grass cover has become greatly reduced and shrubs greatly increased in them (Gardner, 1951; Cooperrider and Hendricks, 1937; Whitfield and Beutner, 1938; Leithead, 1959 and Humphrey, 1958). Most workers appear to have considered these communities as grazing disclimax of the Desert Plains Grassland, but Humphrey (1958) considered that fire originally maintained the grassland against invasion and dominance by shrubs.

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The Problem

As Humphrey (1958) has pointed out, if these creosotebush communities had a climatic potential for grassland within the historic period, they still have that potential; since any significant change in climate over this period must be ruled out. The same does not hold for edaphic factors, however, and it has been suggested that soil changes may be of such magnitude as to prevent or greatly impede an improvement process. Ellison (1960) indicated that loss of topsoil from rangelands may represent a critical alteration of environment and that successional improvement under such conditions might proceed very slowly and with great difficulty. Whitfield and Beutner (1938) pointed out that one of the important problems facing investigators in the Desert Plains Grassland was the determination of the influence of overgrazing, drought and erosion in altering the original vegetation and also their influence in the process of recovery. Gardner (1951) indicated that if general deterioration of soil has taken place in the creosotebush type, improvement may be dependent upon profound soil changes. He added, however, that with adequate protection, a series of moist years and an adequate seed supply, grasses might become restored to the type with soil conditions as they are. The present study was made to determine the condition of the soil of well developed disclimax creosotebush types in south central New Mexico with respect to infiltration characteristics, certain physical and chemical characteristics and the capacity to support establishment and growth of certain of the climax grasses of the Desert Plains Grassland.

Review of Literature

The thesis of change in vegetation in the creosotebush type is fairly well supported, but there is little information as to changes in the soils of the type, or the present capacity of the soils to support growth of the former Desert Plains Grassland dominants. Cooperrider and Hendricks (1937) reported erosional loss of soil in the creosotebush type running from onetenth to three inches. Gardner (1951) stated that top soil has been removed from wide areas of the creosotebush type as evidenced by exposure of tap roots of shrubs. Exposure of tap roots from four to eight inches were reported, without implying,

Table 1. Certain climatic, physiographic and vegetative characteristics of the four sites selected for study.

Characteristic	Sites			
	Cuchillo	Nunn	Stover	Winders
Location	3 mi. north of Cuchillo	20 mi. north of Deming	9 mi. north of Tularosa	4 mi. east of Rincon
Average annual precipitation (inches)[1]	8 to 8.5	10 to 10.5	9 to 9.5	8.5 to 9
Topography				
Slope (per cent)	.5 to 1.0	1 to 1.5	2 to 5	.1 to .2
Direction	easterly	easterly	westerly	easterly
Soil[2]				
Great Soil Group	Calcisol	Red Desert	Calcisol	Red Desert
Type	Chamberino Sandy loam	Mohave sandy loam	Reeves sandy loam	Cacique sandy loam
Depth to carbonate horizon (inches)	20	22	6 to 12[3]	15 to 22
Erosion loss (inches)	1 to 2	1 to 4	6 to 8	0 to 2
Vegetation[4]				
Creosotebush canopy percent	2.74	8.62	8.28	10.91
Other shrub canopy (percent)	.87	3.21	.00	.29
Perennial grass basal area (percent)	.11	.25	.20	.03

[1] Precipitation values for the study sites as estimated from U. S. Weather Bureau Records for the following stations:

Cuchillo: Elephant Butte Dam, 12 miles SE, 53 years average 8.44 inches.
Nunn: Florida, eight miles SE, 22 years average 10.02 inches.
Stover: Tularosa, nine miles S, 48 years average 9.22 inches.
Winders: Jornada Exp't. Range, 15 miles ESE, 45 years average 8.93 inches.

[2] The soil group and type classifications are based on old soil survey reports, unpublished soil survey reports and general knowledge and were furnished on a tentative basis by Prof. J. U. Anderson of the N. M. State University, Department of Agronomy.

[3] At the Stover site a dense, high gypsum mass occurred instead of the indurated carbonate of the other sites.

[4] Vegetation values are from belt transect sampling on shrub and grazing influence plots at the four study sites.

however, that this was a representative measure of soil loss for large areas. Leithead (1959) cited erosion as forming a desert pavement, but did not indicate the actual depth of soil loss. None of these workers reported qualitative changes in the soil, either in physical or chemical properties.

Several studies have shown that soil of upper horizons is the more fertile portion of soil profiles and that, as topsoil is removed, fertility of the exposed surface decreases. As early as 1918, Sampson and Weyl (1918) showed that eroded surfaces of range soil had deteriorated in physical and chemical characteristics by comparison with uneroded surfaces and the deterioration was of sufficient magnitude to have a marked influence on plant production. Paulsen (1953) compared the soil under perennial grass with that under mesquite (*Prosopis juliflora* (Swartz) DC.) in southern Arizona and found that the mesquite soil had undergone slight but definite deterioration in both physical and chemical properties. He concluded that deterioration in physical characteristics was of greater significance and that the deteriorated soil was more favorable for the reproduction of mesquite than of the perennial grasses. However, deterioration was not so great as to prevent the re-establishment of the perennial grasses following mesquite control. Yang[2], in a study of the soils of creosotebush communities and adjacent non-creosotebush areas in the vicinity of Tucson, Arizona, found that coarse materials (2 mm +) tended to run higher in the creosotebush soils and were consistently and materially higher from the surface down to 24 inches. Moisture equivalent down to 24 inches tended to be about a third lower for the creosotebush soils. Total nitrogen tended to be very slightly lower for the creosotebush soils. There was no implication of deterioration for the creosotebush soils or of difference in productivity between the two groups of soils.

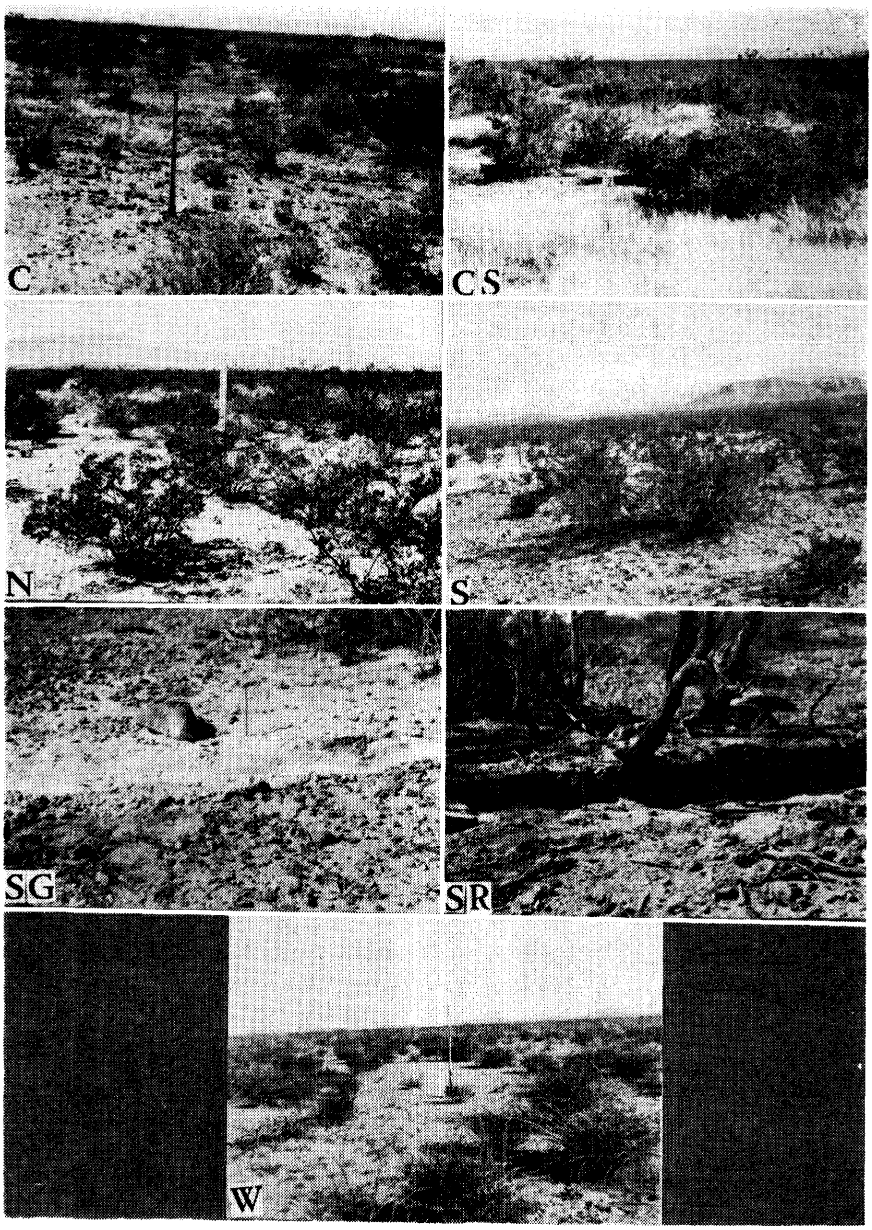

FIGURE 1. General view of the several sites and sub-sites. C—Cuchillo; CS—Cuchillo Successional; N—Nunn; S—Stover; SG—Stover Gypsum; SR—Stover Residue; W—Winders.

Gardner and Keppel (1961), in southeastern Arizona, found that a brushy watershed dominated by whitethorn (*Acacia constricta* Benth.), tarbush (*Flourensia cernua* DC.) and creosotebush lost soil at a rate 3.7 times as great as an adjacent grass covered watershed. Johnson[3] stud-

[2] *Yang, Tien Wei. The Distribution of* **Larrea divaricata** *in the Tucson Area as Determined by Certain Physical and Chemical Factors of the Habitat. Master's Thesis, University of Arizona, Tucson, Arizona, 1950.*

[3] *Johnson, Donald E. Edaphic Factors Affecting the Distribution of Creosotebush* **Larrea tridentata** *(D. C. Cav.) in Desert Grassland Sites of Southeastern Arizona. Master's Thesis, University of Arizona, Tucson, Arizona, 1961.*

ied contiguous grass and shrub communities in southeastern Arizona Desert Plains Grassland and found edaphic differences between grass and shrub environments which were considered to have been effective in maintaining the community differences. Relatively shallow soil, erosion pavement, and low capacity for available moisture were found for soils supporting creosotebush. Whether these characteristics were critically inimical to the establishment of grasses on the creosotebush soil was not indicated.

Methods

Four sites were selected to represent the creosotebush disclimax in southern New Mexico. These sites vary somewhat in climate, topography and soil, but as a group they represent the disclimax as indicated by gentle topography and relatively deep soil. Descriptive details covering the sites are presented in Table 1 and they are illustrated in Figure 1.

Physiographically the Winders site represents the closest approach to sites which are known to possess a grassland potential. In fact, similar sites in the same general vicinity, uninvaded by creosotebush, presently support Desert Plains Grassland communities of varying species composition and successional status. This study site was more heavily invaded by creosotebush and more fully depleted with respect to perennial grasses than the other study sites.

At the Cuchillo site, a sub-site, Cuchillo Successional, representing successional improvement induced by longtime (approximately 30 years) protection from livestock was observed. This sub-site was included in the study to determine whether differences existed between it and the main site and their influence, if any, on plant response.

At the Stover site two sub-sites were observed along with the main site. One of these, Stover Gypsum, consisted of scattered outcrops of high gypsum soil exposed by recent continuing erosion of from six to eight inches of soil. Vegetation was sparse and depauperate or entirely lacking on this sub-site. The second variation of the Stover main site, Stover Residue, consisted of low, broad soil pedestals six to ten inches above the surface and from three to ten or more feet across. These pedestals were generally capped by dead or unthrifty living alkali sacaton (*Sporobolus airoides* (Torr.) Torr.), creosotebush and mesquite plants. They were considered to be remnants of a soil layer once more prevalent or continuous on the main site. Runoff from this sub-site appeared to be high.

Twenty-five, eight-inch deep pits were used to sample each main site and a lesser number to sample the sub-sites owing to their greater uniformity. Soil for each site and sub-site was thoroughly mixed before use in pot tests and removal of samples for analysis. Chemical and mechanical analyses were made by the New Mexico State University Soil Testing Laboratory. One-third and fifteen atmosphere moisture determinations were made by the porous plate and pressure membrane methods, respectively.

Table 2. Physical and chemical characteristics of the soils of the several sites and sub-sites.

Characteristic	Sites and Sub-sites Cuchillo	Cuchillo Success.	Nunn	Stover	Stover Gypsum	Stover Residue	Winders
Physical							
Sand (percent)	61.4	69.5	73.4	67.4	56.4	63.4	75.8
Silt (percent)	20.6	16.1	19.8	32.6	43.6	36.6	18.4
Clay (percent)	18.0	14.4	6.8	0.0	0.0	0.0	5.8
⅓ Atmos. water (percent)	23.04	23.69	20.67	19.89	37.62	10.89	13.16
15 Atmos. water (percent)	11.23	11.79	10.67	8.51	18.13	4.78	6.44
Avail. water capacity (percent)	11.81	11.90	10.00	11.38	19.49	6.11	6.72
Chemical							
Organic matter (percent)	1.4	2.1	1.7	1.3	0.6	1.5	0.85
pH	8.05	7.95	7.98	8.10	7.90	8.05	8.10
Gypsum (percent)	.03	.03	.03	3.1	25.8	.52	.03
Total soluble salts (percent)	.12	.13	.15	.14	.13	.18	.05
Exchangeable sodium (percent)	12	5	8	10	3	12	14
Nitrate (p.p.m.)	19	16	4.5	4.5	3	30	3
Avail. phosphorus (p.p.m.)	1.5	.5	1.0	.5	.5	2.5	.5
Infiltration							
Soil moisture (percent)	1.85	2.05	1.21	.91	13.71	.80	2.09
Infiltration capacity							
15 min. (In./hr.)	2.04	7.96	4.03	6.11	7.13	6.14	4.10
30 min. (In./hr.)	1.40	5.80	2.93	4.33	5.24	4.76	3.20
60 min. (In./hr.)	.98	4.50	2.20	3.08	4.00	3.84	2.55

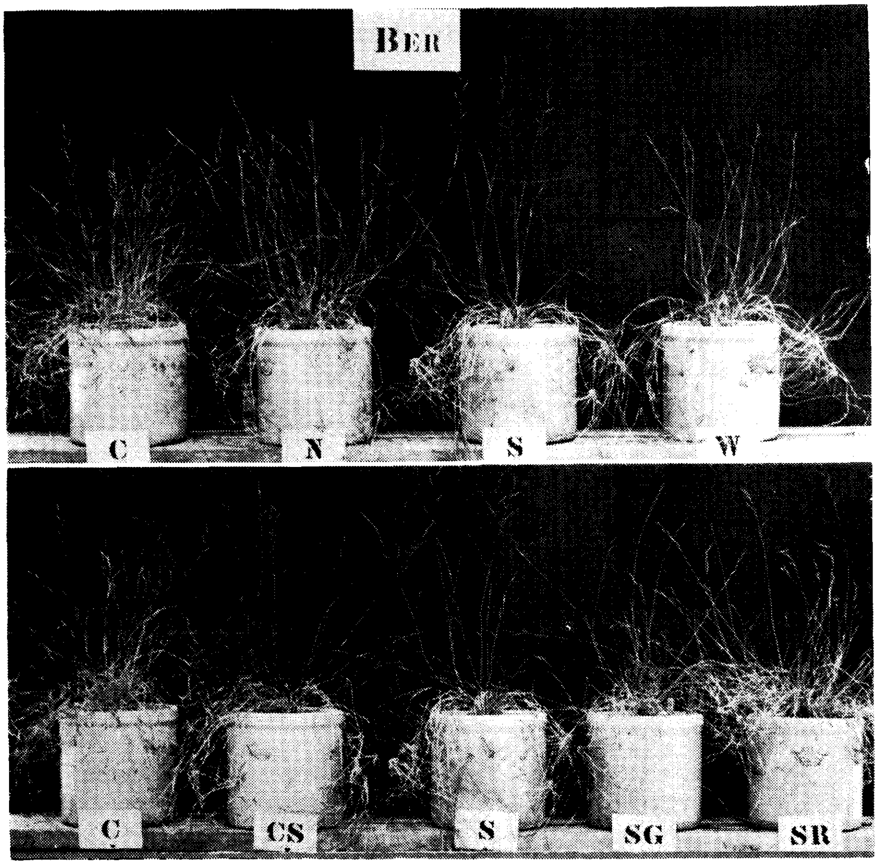

FIGURE 2. Second year growth of black grama transplants. C—Cuchillo; N—Nunn; S—Stover; W—Winders; CS—Cuchillo Successional; SG—Stover Gypsum; SR—Stover Residue.

Infiltration values were determined in the field by means of 8.66-inch diameter infiltration rings driven into the soil to a depth of 3¼ inches and surrounded by a 24-inch buffer ring. This ring kept the surface flooded and reduced the outward flow from beneath the infiltration rings. Water was supplied from 1.85-inch diameter calibrated tubular reservoirs suspended over the infiltration rings through rubber tubing fitted with sprinkler tips. The soil surface within the infiltration ring was kept lightly flooded during test runs. Curves were made from six-minute interval readings for 60 minutes and average rates at 15, 30 and 60 minutes read from the curves. Determinations were made in pairs, two pairs to each site and sub-site. Moisture samples of the surface inch of soil were taken in connection with each infiltration run.

Black grama *(Bouteloua eriopoda* (Torr.) Torr.) and alkali sacaton were used as pot test species. Twenty selected single caryopses were spot planted ¼ inch deep in two concentric circular rows in two-gallon pots. Pots were arranged on the greenhouse floor in four randomized blocks with each species and site and sub-site soil represented in each block. Emergence and survival values were recorded 25 days after planting. Pots were continued in the greenhouse for 45 days and then transferred to an outdoor location in the same randomized block arrangement. After an additional 30 days, surviving seedlings were removed for measuring and weighing.

At the time the seedling emergence and survival observations were made, a small black grama or alkali sacaton plant, matched within species, was transplanted to the central position in each pot without disturbance to the seedlings. Species assignments to pots were the same as for the seedlings. In October 1960 tops of all plants were harvested to a stubble height of two inches. After overwintering in the greenhouse, the pots were again placed outside, arranged as previously. The 1961 regrowth was harvested in October, again at a two-inch stubble height. Duncan's multiple range analysis (Steele and Torrie, 1960) was used to test for significance of differences in performance of seedlings and transplants.

Results

Physical and Chemical Characteristics of Soils

Physical characteristics of the soils of the four sites exhibited a degree of diversity which was not unexpected, considering the difference in parent material and topography, Table 2. At the same time, they were highly similar. They were all predominantly sandy and possessed good surface and sub-surface drainage, characteristics which have been found generally associated with creosotebush communities.

The comparatively high clay content of the Cuchillo soil did not appear to be typical of most creosotebush communities in southern New Mexico. These are usually on well drained, upland topography from which much of the finer soil material has been removed by erosion. The high clay can probably be accounted for by the fact that the site was formerly basin floor with a characteristic higher content of fines, later converted to upland by incision of tributary drainages to the Rio Grande (Bryan, 1938). The zero clay value for the Stover soils, both main site and sub-sites, was also notable. It seems probable, however, that these soils had at least a small quantity of clay, but it may have been flocculated by the high gypsum content of the soil, even in the presence of the dispersion agent used in the mechanical analysis.

The low available water capacity of the Winders soil is probably not an adverse factor to plant production under the prevailing low precipitation, since it is associated with a correspondingly low 15 atmosphere value. In fact, soil with the textural and water supply characteristics exhibited at the Winders site would seem to be well suited to the support of maximum plant response under limited precipitation and without floodwater. Some of the best development of Desert Plains Grassland on the Jornada Plain occurs on very similar soil.

The difference in sand content between the Cuchillo Successional sub-site and the main site is noteworthy in that the sub-site occurs as a series of vegetated spots on the main site, without original environmental differences. It appears probable that the vegetated spots, starting successionally with burrograss (*Scleropogon brevifolius* Phil.), slow down the sediment laden runoff water passing over the site so that the heavier sand fraction is dropped, thus increasing the sand content at these locations.

The Stover Gypsum soil exhibited very high one-third and 15 atmosphere water holding capacities and high available water capacity. This was due in large measure to the inherently high water holding capacity of gypsum and was reflected in the high actual moisture value observed in the field at the time the infiltration tests were made, when the other Stover soils were quite dry. There was no indication in the field, however, that the gypsum soil was actually affording more available water to plants, since plant growth was sparse and unthrifty on this sub-site. This may have been due in part to chemical limitation of the high gypsum soil to the growth of the species present.

The comparatively low total and available water capacity of the Stover Residue soil would seem to make this soil limiting to plant growth in comparison with the other soils, but this did not appear to be the case. The remnant plant material in the surface of this soil, its chemical characteristics and its performance in pot tests, all indicated that this soil had been relatively productive despite its poorer water supply characteristics. This better productiveness may be explained in part by the beneficial influence of a low 15 atmosphere capacity under low precipitation. Also, alkali sacaton, the principal grass species formerly present on this sub-site, is deep rooting and easily capable of drawing water from the underlying Stover main site soil which has better water supply characteristics.

As with the physical properties, chemical properties of the soils showed general similarity. One of the greater chemical differences was the gypsum content of the soil at the Stover site. The Stover Residue and Stover main site soils seemed surprisingly low in gypsum considering the high gypsum content of the Gypsum sub-site soil, its general close proximity to the surface and actual exposure on the surface in numerous places. The vegetation failed to exhibit the gypsophilous species observed on high gypsum soils elsewhere in southern New Mexico (Campbell and Campbell, 1938, Emerson, 1935). The gypsum outcrops may have been too recently exposed for such species to have become established on them. The comparatively high nitrate and phosphorus values of the Stover Residue soil were probably associated with the plant residues which occurred on this sub-site. Differences in these two soil characteristics were probably responsible for the better performance of this soil in the pot tests.

With respect to infiltration capacity, the Cuchillo main site had a relatively low value and the Stover Site was high, with the Nunn and Winders sites intermediate. These probably reflect the amount and condition of clay content. At Cuchillo the high clay content was associated with high replaceable sodium which probably reduced infiltration capacity through dispersion of the clay. The high infiltration value at the Stover site was probably a result of actual low clay content and the flocculating action of the gypsum on the clay present. Branson *et al* (1962) reported such a condition after infiltration tests on Montana range soils with gypsum saturated water as compared to tap water.

The great difference in infiltration between the main Cuchillo site and successional sub-site was directly due to observable difference in structure in the field. The main site soil was almost entirely without surface structure while the sub-site soil exhibited an open, structured and creviced condition. This was induced by organic matter and plant activity in the high clay soil and maintained against destruction through trampling or raindrop impact by the cover of standing vegetation and litter.

The high infiltration value of the Stover Gypsum sub-site was surprising in view of the crusted nature of the surface and the compact, structureless condition beneath the surface. This high value was probably induced by the strong affinity and high capacity of gypsum for water and the flocculated condition of the small amount of clay present. This sub-site was more moist at the time of infiltration tests than the main site and Residue soils and it seemed probable that

Table 3. Growth response of black grama and alkali sacaton seedlings and transplants in soils of the several sites and sub-sites.

		Sites and Sub-sites						
Response	Species	Cuchillo	Cuchillo Success.	Nunn	Stover	Stover Gypsum	Stover Residue	Winders
Emergence (percent)	Black grama	41.25	33.75	33.75	61.25	36.25	63.75	65.00
		a[1]	a	a	b	a	b	b
	Alkali sacaton	46.25	56.25	35.00	75.00	38.75	71.25	67.50
		a,b	a,b,c,	a	c	a	c	b,c
Survival (percent)	Black grama	54.75	3.50	32.00	23.25	15.00	50.50	65.75
		c,d	a	a,b,c,d	a,b,c	a,b	b,c,d	d
	Alkali sacaton	65.50	33.75	40.75	55.25	28.75	98.00	79.50
		c	a	a,b	a,b,c	a,b	d	c,d
Seedling height (cm)	Black grama	17.3		26.1	13.3		21.0	27.7
		No significant differences						
	Alkali sacaton	10.1	8.1	24.5	8.5	2.5	34.5	27.0
		b	b	c	b	a	d	c
Seedling weight (grams)	Black grama	.15		.30	.06		.24	.28
		a,b,		c	a		b,c	c
	Alkali sacaton	.05	.04	.36	.02	.005	.38	.25
		a	a	b	a	a	b	b
Transplant weight (grams)	Black grama	12.08	16.41	12.53	10.59	7.30	12.34	9.45
		b	c	b	b	a	b	a,b
	Alkali sacaton	7.62	7.73	7.19	7.25	6.01	10.86	6.91
		a	a	a	a	a	b	a

[1]Values to which different letters are subscribed differ from each other at the .05 probability level.

established capillary films increased the rate of water intake.

The infiltration capacities determined may appear to be adequate considering the low total annual precipitation characteristic of creosotebush sites. However, there generally are one or more rainstorms of sufficient intensity during the summer season to exceed these capacities with the loss of considerable water from sites on sloping topography. These data do not permit comparisons between present infiltration capacity and original capacity; however it seems safe to conjecture that infiltration capacity has decreased and runoff increased with the loss of perennial grass cover and the more absorptive upper soil layers. Certainly any runoff from creosotebush sites represents an adversity of environment under the characteristic low precipitation. The infiltration capacity value for the Cuchillo Successional sub-site cannot be used as a standard of original condition or infiltration potential for creosotebush sites in general, owing to the post-climax nature of this sub-site and the high clay soil which forms excellent structure under high level plant reaction. This condition of cover and soil cannot be expected to develop in most of the creosotebush area. It seems safe to conclude, however, that infiltration capacity of the soils observed has not been critically impaired, since the Cuchillo soil with the lowest infiltration rate is capable of supporting successional improvement.

Pot Tests of Soils

Black grama seedling emergence was significantly lower in Cuchillo and Nunn soils than in Stover and Winders soils (Table 3). With alkali sacaton the Nunn soil showed low emergence, the Cuchillo and Winders soils intermediate and the Stover soil the highest seedling emergence. The higher emergence tended to show association with low clay and low 15 atmosphere moisture values. The Cuchillo Successional soil showed no difference from the main site for either species. This was also true of the Stover Residue in comparison with its main site, but the Stover Gypsum showed low emergence in comparison with the main site. The Cuchillo, Cuchillo Successional and Stover Gypsum soils formed conspicuous hard crusts in the pots, which probably had an adverse influence on emergence. Under field conditions much of the surface of the Cuchillo Successional soil was protected from raindrop impact by standing plant cover and litter and the crusted condition observed in the pots did not exist.

Survival of black grama seedlings exhibited a significant difference only between the Stover and Winders soils among the main sites with the Stover soil showing the lower value. Alkali sacaton showed survival differences only between the Nunn and Winders main site soils. The Cuchillo Successional soil gave significantly lower survival than

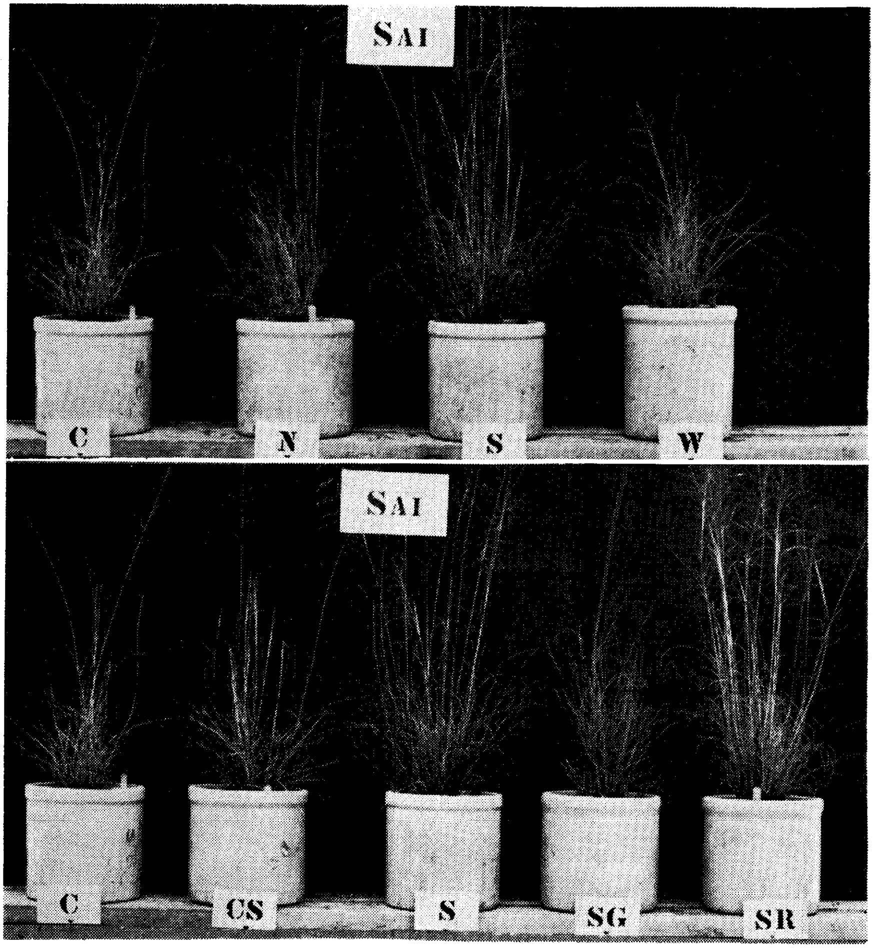

FIGURE 3. Second year growth of alkali sacaton transplants. C—Cuchillo; N—Nunn; S—Stover; W—Winders; CS—Cuchillo Successional; SG—Stover Gypsum; SR—Stover Residue.

the main site soil for both species. On the Stover Residue, alkali sacaton survived significantly higher than on the main site soil. The failure of the black grama seedlings to survive in the Cuchillo Successional soil till the date of removal for measuring and weighing may have been due in part to competition from the transplants which were significantly larger in this soil than in any of the others. This failure need occasion no doubt as to the capacity of this soil to support black grama as is evidenced by both the transplant test results and the fact that this species grows thriftily in the field on this sub-site.

Black grama seedlings exhibited no significant differences in height growth in the pot test. Alkali sacaton seedlings made significantly greater height growth in the Nunn and Winders soils than in the Cuchillo and Stover main site soils. Height growth of sacaton seedlings was significantly higher in the Stover Residue soil and significantly lower in the Stover Gypsum soil than in the main site soil. Expressed in terms of weight, both black grama and alkali sacaton seedlings made greater growth in the Nunn and Winders soils than in the Cuchillo and Stover soils. These differences do not appear to be related to the soil characteristics. Among the sub-site soils, the only significant difference was for seedling growth in the Stover Residue soil, which produced the greater growth with both species. This was probably a response to the higher nitrate and available phosphorus content in this soil.

Top growth of transplants of both species showed no significant differences among any of the main site soils. The Cuchillo Successional soil supported significantly more growth and the Stover Gypsum soil significantly less growth of black grama transplants than the corresponding main site soils. The Stover Residue soil supported significantly more growth of alkali sacaton transplants than the main site soil.

Production of tops of both test species was as great in the Cuchillo, Nunn and Stover soils as in the Winders soils. The Winders soil was believed to represent minimal and non-critical deterioration from well preserved, productive desert grassland soil as it generally occurs on upland sites in southern New Mexico. Approximately equal thrift of growth and development, as shown in Figures 2 and 3, were obtained in all main site soils with both species. The vigorous stolon production exhibited by black grama in all soils was particularly important. This is the chief method of reproduction in this valuable climax dominant under natural conditions.

Discussion and Conclusions

While some differences among the main site soils have been revealed, all these soils appear to be capable of supporting the successful establishment and growth of the test species.

It must be recognized, however, that relative results under field conditions might be different from those obtained in the pot tests. The infiltration capacity and topographic differences between sites through their influence on soil moisture would be expected to induce some differences in plant performance in the field.

Results obtained for the Cuchillo location indicated that the main site was capable of supporting the improvement observed on the successional subsite. Long time soil improvement, a possibility suggested by Gardner (1951), and Ellison (1960) did not appear necessary to support vegetation improvement. On this site, conditions appeared to resemble those pointed out by Paulsen (1953), in that physical soil conditions were more adverse to seedling establishment than chemical conditions. The most critical limitation appeared to be the crusted condition of the soil surface. This condition seemed to be readily modified with the establishment of burrograss, which by virtue of its abundant seed production, sharp callused fruit and drought tolerance was well adapted to pioneer this site. The low surface grade at this site may have offset to some extent the tendency of the low infiltration capacity of the soil to accelerate runoff.

At the Nunn site the lower infiltration capacity in combination with the greater surface gradient tended to induce runoff and make growing conditions less favorable. The slightly higher rainfall indicated for this site might have offset loss by runoff to a degree. If so, this site may be equal in grass supporting potential to the others.

Results for the Stover location indicate that the main site has good potential for grassland. Although infiltration capacity was above average, the surface gradient induced runoff. In fact, the area does lose water as runoff as shown by a well developed drainage system. The residue sub-site pointed strongly to deterioration from a more productive soil which formerly existed on the site. Much more serious, however, was the incipient deterioration of the main site by increasing gypsum outcrops. Despite the indications from the pot tests, of some, if reduced, grass potential, this sub-site gives every indication in the field of being extremely adverse to grass establishment and growth. The crusted surface of the soil affords a very poor environment for seed lodgment and germination and the high gypsum soil an equally poor environment from the standpoint of availability of water and nutrients.

The Winders site location appeared fully adequate for the support of the Desert Plains Grassland climax dominants. Although the infiltration capacity was such that torrential rainfall would not be taken into the soil quickly, the very low surface grade would tend to suppress runoff. Indications in the field were that micro-relief served to prevent much runoff.

It was concluded from the study that while the vegetation on the study sites had undergone marked deterioration, the soil retained the capacity to support the establishment and growh of the better Desert Plains Grassland species. Results and observations on the Stover Site indicated that a significant degree of soil deterioration had already taken place as measured in terms of plant production, and that further serious deterioration was imminent, a deterioration from which the liklihood of recovery appeared remote. Management practices, such as removal of the established shrub cover and regulation of grazing and trampling to a non-destructive degree, to restore a soil protecting, soil building productive cover were indicated for all sites.

Summary

This paper presents the results of a study of physical and chemical properties of soils of four selected creosotebush sites in southern New Mexico. The soils remain capable of supporting establishment and growth of the climax dominant grasses, although deterioration through erosion, and in one case loss of structure, has occurred. One site appeared to have lost soil to the extent that production capacity for the test species had been significantly reduced. At the same site, continuing erosion threatened to further reduce soil productivity by exposure of an underlying high gypsum substratum. Range management practices consisting of proper grazing management and control of creosotebush to preserve and improve these range areas were strongly indicated.

LITERATURE CITED

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