Effects of Soils on Forage Utilization in the Desert Grassland[1]

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Highlight

This study was made in southeastern Arizona to determine some of the factors affecting utilization by cattle of two key species on three desert grassland soils. Results showed that macronutrient content of the soil and the plants, and corresponding utilization of blue grama (*Bouteloua gracilis*) and curlymesquite (*Hilaria belangeri*), were always significantly greater on the Pima bottomland soil than on the two upland soils, but they were not always significantly different between the two upland soils. No consistent relationships were found between forage utilization and micronutrient, sugar or starch content in the plants.

El Efecto de Suelos Sobre el Consumo de Forraje en una Pradera Desertica

Resumen[2]

El estudio se llevó a cabo en una zona desértica en el Estado de Arizona, E.U.A. Hubo una correlación significativa entre el consumo de forraje y los contenidos de nitrógeno, fósforo y potasio. No hubo una correlación entre el consumo y los contenidos de azúcar, almidón, micronutrientes ni humedad. El consumo fué mucho más significativo en cuanto al forraje en los valles con suelos profundos que en los suelos de las dos mesetas.

The purpose of this study was to determine the effects of selected soil and plant characteristics on the utilization by cattle of two key grass species on three different soils in the desert grassland of southeastern Arizona.

Study Area and Methods

The study was conducted in 1968 in a 30-acre pasture on the Elgin Ranch, located one mile west of Elgin, Arizona. The pasture is open desert grassland at an elevation of 4700 ft. Precipitation during the summer of 1968 was 8.2 inches, slightly below the average summer precipitation of 10 inches. The pasture was grazed by 4 head of 500-lb. weaner steers and 1 cow from July 16 to October 11.

The desert grassland is characterized by low annual precipitation, short erratic rainy seasons, high temperatures, high wind velocities and rapid evaporation (Humphrey, 1968). Most of the grass species belong to the three genera, *Bouteloua*, *Hilaria*, and *Aristida*. The species investigated in this study were blue grama (*Bouteloua gracilis*) and curlymesquite (*Hilaria belangeri*). These species are palatable and nutritious grasses in the desert grassland (Humphrey, 1970).

Soils in the study area were developed from mixed alluvium under high temperature and low rainfall conditions (Buol, 1965 & 1966). Topsoils are generally dark colored, medium to moderately fine textured, and usually contain 1 to 2% organic matter. Subsoils are moderate to fine textured and contain appreciable amounts of carbonate.

The three soil series in the study area—Bernardino, Hathaway and Pima—are described in detail in the 1970 National Cooperative Soil Series Descriptions.[3] The predominant Bernardino series has a shallow dark brown gravelly clay loam A horizon 1 to 3 inches thick, a dark reddish-brown gravelly clay B horizon 10 to 20 inches thick, and a gravelly C horizon high in calcium carbonate at 15 to 20 inches. The pH ranges from 7.5 at the surface to 8.0 in the subsoil. Hathaway has a dark grayish-brown gravelly loam A horizon 7 to 16 inches thick over a light gray C horizon that ranges from gravelly loam to a very gravelly loamy sand 10 to 40 inches thick. It is calcareous throughout, ranging from pH 8.0 to 8.2, and has a layer of caliche at 7 to 16 inches.

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[1] Paper No. 1669 Arizona Agricultural Experiment Station, Tucson. Study financed in part by the National Science Foundation. Received July 8, 1970; accepted for publication June 6, 1971.

[2] Por Donald L. Huss and Benjamín López, Dep. de Zootecnia, ITESM, Monterrey, México.

[3] Soil series description for Bernardino, Hathaway and Pima Series approved in 1970, National Cooperative Soil Survey, USA.

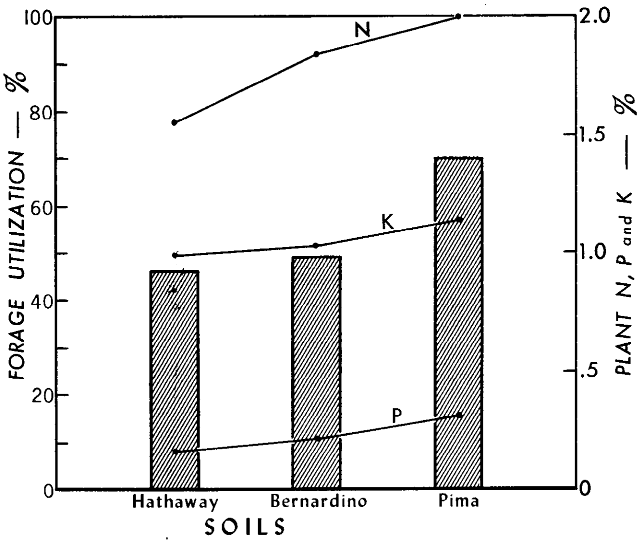

FIG. 1. Relation of forage utilization to the nitrogen, phosphorus, and potassium content of blue grama on three desert grassland soils.

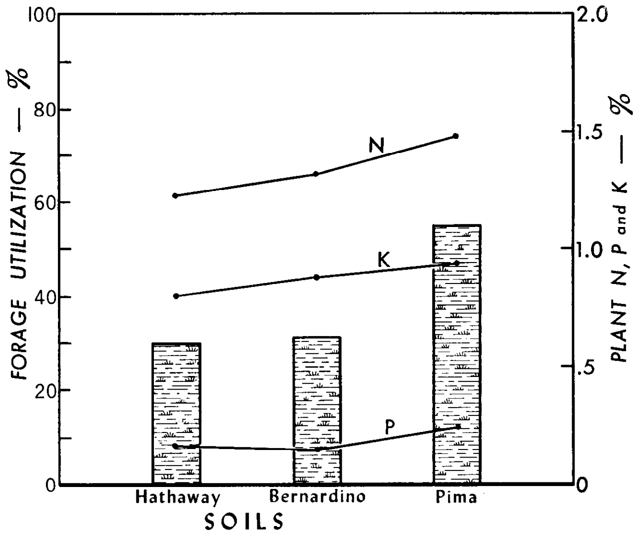

FIG. 2. Relation of forage utilization to the nitrogen, phosphorus, and potassium content of curlymesquite on three desert grassland soils.

Pima has a dark grayish-brown clay loam A horizon 20 to 36 or more inches thick and a clay loam C horizon that ranges from 20 to 40 inches thick. The pH normally ranges from 7.5 at the surface to 8.0 in the C horizon but doesn't form a caliche layer. Predominant slopes on the Bernardino soils range from 2 to 15%, Hathaway 10 to 40%, and Pima 0 to 3%.

This study was made on eight sample plots, 50 feet by 250 feet, established on each of the soil types. Plots were delineated by placing a stake at each corner.

Composite soil samples of 16 cores were taken between August 28 and September 1, 1968, according to the requirements outlined by Jackson (1965). Cores were taken along a zig-zag path at every other step. Samples were then mixed on a plywood board and a composite sample was taken for lab analyses. Chemical analyses were made for water holding capacity, pH, soluble salts, nitrate, phosphate, and potassium by the University of Arizona Soil and Water Testing Laboratory.

Composite samples of blue grama and curlymesquite were taken at random in each plot between August 14 and 17, 1968. The same procedure of following a zig-zag line within the plots was used in securing plant samples, but the leaves were clipped from each plant along the line rather than at every other step. Both species on all soils were in the vigorous stage of leaf growth prior to initiation of seedheads. The clipped leaves were held in plastic bags on dry ice until oven-dried for 24 hours at 80 C. Moisture content, nitrogen, phosphorus, potassium, magnesium, iron, zinc and copper were determined by the University of Arizona Soil and Water Testing Laboratory. The sugar content of the plant was determined by extracting with 80% ethanol and determining sugars using anthrone reagent. Starch (including other nonstructural polysaccharides) was extracted using perchloric acid. The optical density of the plant sugar and starch extracts with anthrone were compared with a standard of glucose (White, 1968).

The grazed-class method of estimating utilization (Schmutz, Holt, and Michaels, 1963) was used to determine forage utilization. Toe-pace 100 plant transects were made by two experienced examiners for each species on each soil between October 15 and 23, 1968, immediately after the grazing period. Estimates by the two examiners were averaged for percentage utilization.

Results and Discussion

Utilization

Utilization of blue grama and curlymesquite was significantly higher on the Pima bottomland soil than on the two upland soils (Fig. 1 and 2). There was no significant difference in utilization of either species between the shallow calcareous Hathaway upland soil and the deeper less calcareous Bernardino upland soil.

Nitrogen

Nitrate content of the soil was significantly higher in the Pima bottomland soil than the two upland soils (Table 1). There was no significant difference in the nitrate content of the Hathaway and Bernardino upland soils. Nitrogen content of

Table 1. Characteristics of three desert grassland soils.

Factor	Mean content of soils		
	Hathaway	Bernardino	Pima
Water holding capacity (%)	8.56 b[1]	6.01 a	12.26 c
pH	7.80 c	6.80 b	6.10 a
Salts (ppm)	311.00 a	353.00 a	294.00 a
NO_3 (ppm)	4.63 a	4.75 a	10.20 b
PO_4 (ppm)	.61 a	.74 a	8.10 b
K (ppm)	4.06 a	4.38 a	5.83 b

[1] Means followed by the same letters are not significantly different at the 5% level (Duncan, 1955).

Table 2. Percentages of various components in blue grama from three desert grassland soils.

Component	Mean content of blue grama by soils		
	Hathaway	Bernardino	Pima
N	1.56 a[1]	1.84 b	2.00 c
P	.17 a	.21 b	.31 c
K	.98 a	1.03 a	1.13 b
Mg	.10 a	.12 b	.10 a
Fe	.0041 a	.0085 b	.0050 a
Cu	.0026 a	.0035 b	.0018 a
Zn	.0027 a	.0039 b	.0022 a
Moisture	51.83 c	48.86 b	45.46 a
Sugar	.045 a	.042 a	.045 a
Starch	.020 a	.043 b	.026 a

[1] Means followed by the same letters are not significantly different at the 5% level (Duncan, 1955).

Table 3. Percentages of various components in curlymesquite from three desert grassland soils.

Component	Mean content of curlymesquite by soils		
	Hathaway	Bernardino	Pima
N	1.23 a[1]	1.31 b	1.47 c
P	.17 a	.15 a	.24 b
K	.80 a	.88 b	.94 c
Mg	.08 a	.12 c	.11 b
Fe	.0062 a	.0061 a	.0061 a
Cu	.0043 b	.0036 ab	.0031 a
Zn	.0035 a	.0034 a	.0034 a
Moisture	51.65 b	47.66 a	50.18 ab
Sugar	.049 a	.057 ab	.064 b
Starch	.025 a	.019 a	.027 a

[1] Means followed by the same letters are not significantly different at the 5% level (Duncan, 1955).

both grasses was significantly higher on the Pima soil, intermediate on Bernardino and lowest on Hathaway (Tables 2 and 3). The significantly higher nitrate content of the Pima soil was probably due to its higher water-holding capacity (Table 1) which resulted in greater nitrogen mineralization and uptake of nitrogen by the plants (Black, 1960). There was a direct relationship between forage utilization and nitrogen content of the plants (Fig. 1 and 2). This was similar to that noted by Stroehlein, Ogden, and Billy (1968), and probably resulted from higher nitrogen content in the plant tissues which influenced plant palatability.

Phosphorus

Phosphorus content of the soil was markedly greater in the Pima soil, than the two upland soils (Table 1). The difference between the Hathaway and Bernardino soils was not significant. Similarly, phosphorus content of both grasses was significantly higher on the Pima soil (Tables 2 and 3). Phosphorus content of blue grama was significantly higher on the Bernardino than the Hathaway soil but the difference in phosphorus content of curlymesquite on the two soils was not significant. The lower phosphorus content of both grasses on the Hathaway over the Pima, and blue grama on the Hathaway over the Bernardino, may have been influenced by pH since availability of soil phosphorus declines rapidly as soil pH increases from neutral to above 8.0 (Millar, Turk, and Foth, 1958; Olsen and Fried, 1957). As in the case of nitrogen, the higher phosphorus content of the plants was associated with greater forage utilization (Fig. 1 and 2).

Potassium

Potassium content of the soil was considerably higher in the Pima soil than the two upland soils (Table 1), but there was no significant difference between potassium content of the two upland soils. The potassium content of the two grasses was also significantly higher on the Pima soil (Tables 2 and 3). The potassium content of curlymesquite, but not blue grama, was significantly higher on the Bernardino than the Hathaway soil. The lower potassium content of both species on the Hathaway over the Pima, and curlymesquite on the Hathaway over the Bernardino, may have been influenced by pH (Millar et al., 1958; Olsen and Fried, 1957). As with nitrogen and phosphorus, higher potassium content in the plants was associated with greater forage utilization (Fig. 1 and 2).

Micronutrients, Starch and Sugar

There was no consistent pattern between the levels of magnesium, iron, copper, zinc, sugar or starch in the two grasses and the soils on which they grew (Tables 2 and 3). Neither was there a consistent relationship between forage utilization and the level of micronutrients, sugar or starch in either plant species (Tables 2 and 3, Fig. 1 and 2). This indicates that micronutrient levels in the soils and micronutrient and carbohydrate levels in the plants had little or no effect on forage use.

General Discussion

The close relationships between utilization and the nitrogen, phosphorus, and potassium in the plant and the soil indicates that the levels of these nutrients in the soil and plant tissue influence forage utilization (Fig. 1, 2 and 3). The amounts of nitrogen, phosphorus, and potassium in plants may affect utilization in many ways. Potassium functions in nitrogen metabolism of plants by coupling amino acids and producing proteins. Therefore, low potassium levels may cause an increase in soluble forms of nitrogen and result in less protein content (Black, 1960). Also, potassium and phosphorus are essential in transphosphorylation reactions that result in the formation of structural and

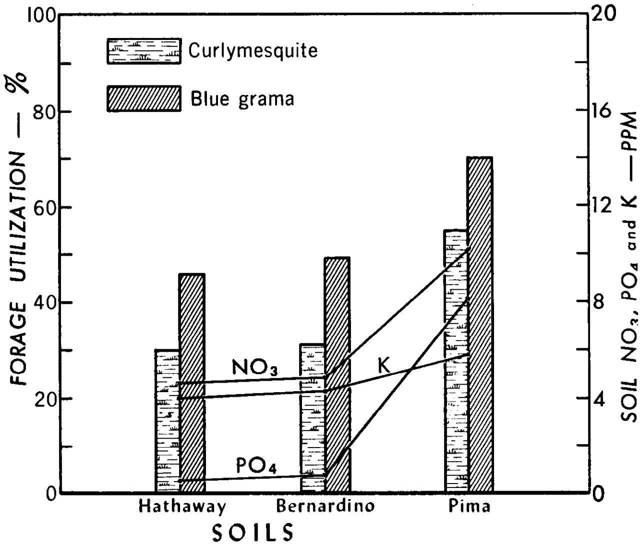

FIG. 3. Relation of forage utilization to nitrate, phosphate, and potassium content of three desert grassland soils.

storage compounds (Black, 1960). The above interactions indicate that there are strong structural-functional interrelationships among nitrogen, phosphorus, and potassium in plants. Because of these interrrelationships the effects of these minerals on palatability and utilization cannot be separated.

This study indicates that fertility of the soil influences plant utilization and this effect on range use must be considered in plans to modify livestock distribution. For example, fertilization of sites low in fertility may be used to improve distribution of grazing.

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