FORAGE ESTABLISHMENT AND SOIL FERTILITY ON A RECLAIMED MINE SPOIL IN WESTERN NORTH DAKOTA

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To return strip-mined lands to a high level of usefulness, it is desirable to know the influence of various soil factors on plant establishment in a mine spoil. The reclaimed Old Pittsburg Mine in Stark County allowed such a study because it has a variety of soil conditions and microenvironments and was seeded with various forage species.

This research deals with establishment and first-year growth of various forage species. When considering yields over an extended period of time, other factors which were not considered in this study are important. These include changes in soil salinity levels (Merrill et al., 1980), the thickness of topsoil (Power, et al., 1981), and normal plant succession.

METHODS

After recontouring the Old Pittsburg Mine spoil near Dickinson, North Dakota, a 3-inch layer of soil was spread throughout the site. This soil was a combination of first- and second-lift materials and in some locations contains appreciable quantities of coal slack.

In October of 1980, a seed mixture containing western wheatgrass (*Agropyron smithii*), tall wheatgrass (*Agropyron elongatum*), green needlegrass (*Stipa viridula*), slender wheatgrass (*Agropyron trachycaulum*), sideoats grama (*Bouteloua curtipendula*), and yellow biennial sweetclover (*Melilotus officinalis*) was drilled approximately ¾ inches deep into the surface soil.

Eight small plots were established at various locations within the 40-acre range to allow data collection from a variety of slopes and soil conditions at known locations. In the spring of 1981 the soils in and around these plots were sampled and analyzed for fertility characteristics (Table 1).

Table 1. Description of experimental plots with soil test data from upper six inches of soil.

	Plot							
Characteristic	1	2	3	4	5	6	7	8
Soil‡	shallow	contains coal slack	—	—	contains coal slack	—	—	—
Slope (& aspect)	level	level	steep slope (W)	steep slope (SW)	gentle slope (S)	steep slope (N)	gentle slope (S)	steep slope (E)
Water holding capacity (%)	34	24	28	29	27	27	32	30
pH (1:1 extract)	8.0	7.9	7.5	8.1	7.5	8.1	7.7	7.6
EC (1:1 extract, mmmho/cm)	1.3	1.8	2.5	1.4	2.0	0.5	2.2	1.8
NO_3—N (ppm)	2	7	2					
Phosphorus (ppm) (Olsen procedure)	3	4	2	2	3	4	2	4
Potassium (ppm) (1N ammonium acetate)	95	140	80	123	105	150	125	103

‡Unless specified, soil was approximately three inches deep and a mixture of first lift and other materials present at the site which appeared to be acceptable for use as topsoil.

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The soils were deficient in nitrogen, phosphorus, and potassium according to standard nutrient testing procedures used on nondisturbed land. These procedures have been found to be applicable to disturbed lands also, but calibration and interpretation may vary (ARS and ND Ag. Expt. Sta., 1977). The soils were also found to have adequate minor nutrients, moderate pH values, and moderately low levels of salinity. Soil textures were loamy. Soils from all plots and sampling depths effervesce in hydrochloric acid, indicating the presence of carbonate and/or bicarbonate.

The site was fertilized by top dressing 320 pounds of 23-9-12 per acre in June 1981. No fertilization preceded planting. Prior to fertilizing, half of each test plot was covered to exclude fertilizer, allowing a comparison between the fertilized and unfertilized treatments.

In November 1981, selected soils were sampled to determine the extent of nitrate build-up in the upper soil. Also on that date, plots 2, 3, and 8 were sampled to compare fertility levels of subplots which did and did not receive fertilizer in June 1981.

For all plant data contained herein, two replications of a 1 square foot area were randomly sampled from each half (fertilized and unfertilized treatments) of each plot. The final plant sampling for yield comparisons was conducted on September 28, 1981. At this time the fresh weights were determined. Dry weights were determined following a four-week drying period. The moisture contents of composite samples for each of the three plant groups (grass, clover, weeds) were determined individually following the curing process and was subtracted from the dry weights.

RESULTS AND DISCUSSION

Plant yields and influencing factors

Plant stand density was measured prior to fertilizing; there were no differences in stand between those plots that would and those that would not receive fertilizer. This early-season stand density measurement did not correlate in a significant way with any measured soil parameters including pH, salinity, or slope, nor did it correlate strongly with final yield.

Yield data are shown in Table 2 for both fertilized and unfertilized plots. The greatest portion of the growth was from weeds, while forage production averages from sweetclover and the grasses were essentially equal. The weed growth was primarily Russian thistle (*Salsola kali*).

Ries et al. (1978) found that although fertilizer application correlated positively to productivity, fertilizer did not necessarily increase stand density. In the present study the fertilizer treatment could not affect stand due to the post-emergence fertilizer application; but, neither did fertilizer improve productivity. The samples from unfertilized plots contained more total plant matter than did those from plots receiving fertilizer (Table 2). The yield difference between fertilized and unfertilized plots was not statistically significant. It is not known why yields failed to respond to fertilizer. Past responses of pasture species to fertilizer have been inconsistant (Wight and Black, 1972; Bauer et al., 1978).

Yields in individual plant categories and of all plant collectively were essentially randomly distributed with

Table 2. Yields from fertilized (and unfertilized) plots.

	Plot								
Plant description	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Mean**
	grams/2 sq. ft.								
Fresh weeds	52.2 (36.5)	3.7 (4.5)	17.8 (11.2)	39.9 (64.8)	1.7 (0.0)	78.6 (139.2)	1.6 (87.0)	6.7 (91.0)	25.3 (54.3)
Fresh Sweetclover	0.4 (1.1)	1.1 (4.4)	10.3 (9.3)	0.0 (0.4)	6.9 (1.0)	0.0 (0.0)	1.0 (1.6)	9.4 (11.8)	3.6 (4.95)
Fresh grass	0.3 (0.1)	3.6 (3.6)	0.6 (4.0)	0.3 (0.8)	6.7 (4.4)	0.0 (0.02)	4.6 (5.2)	1.7 (4.2)	2.2 (2.8)
Fresh total	52.9 (37.7)	8.4 (12.5)	28.7 (24.5)	40.2 (66.0)	15.3 (5.4)	78.6 (139.2)	7.2 (93.8)	17.8 (107.0)	31.1 (60.8)
Dry Weeds	45.1 (32.7)	2.5 (3.6)	13.4 (10.1)	32.4 (46.4)	0.6 (0.0)	65.9 (112.9)	0.8 (79.1)	5.2 (83.3)	20.7 (46.0)
Dry Sweetclover	0.2 (0.8)	0.8 (2.5	5.6 (5.0)	0.0 (0.4)	3.7 (0.6)	0.0 (0.0)	0.6 (1.0)	5.0 (5.9)	2.0 (2.0)
Dry Grass	0.5 (0.3)	2.8 (3.1)	0.8 (3.7)	0.2 (06)	5.9 (3.8)	0.0 (0.1)	3.9 (4.1)	1.6 (3.7)	2.0 (2.4)
Dry total	45.8 (33.8)	6.1 (9.2)	19.8 (18.8)	32.6 (47.4)	10.2 (4.4)	65.9 (113.0)	5.3 (84.2)	11.8 (92.9)	24.7 (50.46)

respect to such soil parameters as salinity, nitrogen, phosphorus, and potassium levels, water holding capacity, slope, and texture. However yields of the seeded grass and clover decreased as pH increased (Figure 1). There were six different pH values (Table 1) among the eight sites and each site provided two composite samples (fertilized and unfertilized) except in the case of the duplicated pH values, where those treatments or plots were sampled four times, for the purpose of the statistical analysis. The pH level significantly affected the total yield of grass-plus-clover (0.01 level).

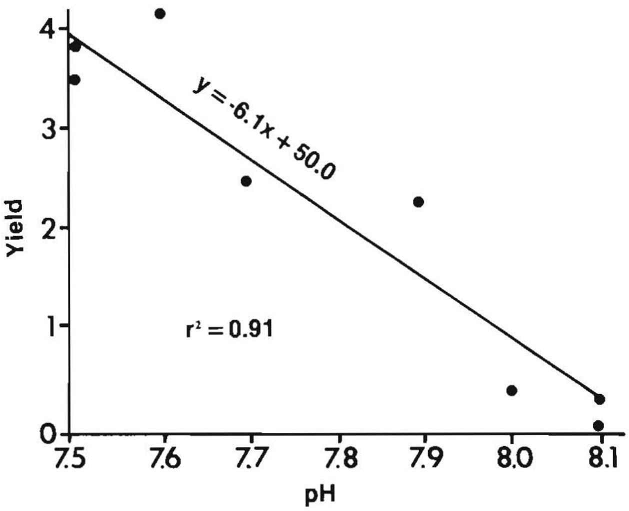

Figure 1. Yield (in grams of dry matter per square foot) of grass plus clover as a function of pH values of soil.

Sodium absorbtion ratios (SAR) were from 5.0 to 0.1 indicating that the soils were not sodic. The reduction in yield as pH values increased may have been due to decreased availability of phosphorus or micronutrients; however, the soils were not difficient in zinc, iron, manganese, copper, or sulfur according to NDSU soil tests.

The site was not grazed in 1981. There were, however, conditions which affected plant yields, including the unusually dry spring followed by near normal precipitation in mid- and late-summer, grasshoppers, and the heavy growth of Russian thistle which normally invades a mine spoil in the early stages of revegetation (Lodhi, 1979).

Soil data

During the growing season, the level of soil salinity frequently decreased while soil pH also decreased slightly. Since fertilizing was accomplished by top dressing, it was of interest to know the extent to which nitrate accumulated in the upper part of the soil. In three areas — a level area, an area receiving run-on water, and an area losing run-off water — nitrate was analyzed in the 0-3 inch depth as well as in the 3-6 inch depth. For the level, run-on, and run-off areas respectively, the nitrate levels in the shallow layer were 1 ppm, 1 ppm, and 1.5 ppm. In the deeper layer, the coresponding nitrate levels were 1 ppm, 1.5 ppm, and 1.5 ppm, suggesting that either the nitrate did diffuse throughout the upper 6 inches and possibly deeper, or that the consumption was greatest in the upper 3 inches. In either case, no surface nitrate build-up occurred.

Following the growing season, fertility levels of selected fertilized and unfertilizeed sub-plots were compared. Average nitrate and phosphorus levels were slightly higher in fertilized plots, while salinity levels and potassium levels were higher in unfertilized plots. From the similarities of fertilized and unfertilized soil data as shown in Table 3, it appears reasonable to assume that there is no appreciable difference in fertility levels in a general sense between fertilized and unfertilized plots.

SUMMARY

Sweetclover and several native grass species were fall seeded into reclaimed soil on the Old Pittsburg Mine site in southwestern North Dakota. A top dressing of NPK fertilizer failed to enhance plant growth; it did, in fact, decrease growth, but not to a significant degree. Neither total salts nor nitrate had significantly accumulated in the upper level of the soil after one growing season. Several soil characteristics were studied and correlated to forage crop yields. Within the pH range of 7.5 to 8.1, forage plant growth decreased significantly as pH increased. Other observed soil properties did not influence forage growth significantly. Weed yields did not correlate significantly to any of the soil properties observed in this study. Most of the plant matter produced the first year came from Russian thistle. There was not sufficient growth after one year to reasonably allow grazing of livestock.

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Table 3. Soil test data from upper 6 inches of soil, comparing fertilized and unfertilized plots.

Plot	Treatment	Nitrogen	Phosphorus	Potasium	pH	EC
		lb/acre				mmho/cm
2	fertilized	3	6	205	7.1	1.4
	unfert.	2	5	230	7.1	1.6
3	fertlized	4	6	190	6.6	1.7
	unfert.	3	5	200	6.8	1.6
8	fertilized	2	3	195	7.3	1.3
	unfert.	2	3	220	7.3	1.5