Effects of Tillage on Water Movement into Surface-Mined Materials

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The effects of tillage on water movement into surface-mined materials of high sodium adsorption ratio were evaluated. The depth of water penetration was measured on plots which were nontilled, moldboard plowed and disked prior to topsoil placement. Tillage produced little effect on increased water flow into the spoil medium.

Increased utilization of coal reserves in western North Dakota is expected as a result of growing national energy needs. An estimated 20.7 million acres in North Dakota are underlain by surface-mineable deposits of coal (1). The projected recoverable coal reserve base of western North Dakota is 12.8 billion tons. By the year 2000, more than 30,000 acres in Oliver and Mercer counties alone are expected to have been committed to energy development. Reclamation procedures need to be developed to restore these lands to acceptable productivity levels.

In presently used procedures, the portions of the soil material considered suitable as plant rooting medium are removed and stockpiled. The overburden is then excavated and placed in the trench resulting from previous stripping activities. The overburden is smoothed and the plant rooting medium replaced.

The excavated spoil is invariably inverted, resulting in a mixing of geologic materials. The spoil material left at the surface often has higher concentrations of sodium than calcium and magnesium. Materials with high sodium adsorption ratio (SAR) disperse readily when exposed to water, and as a consequence, infiltration is reduced. When infiltration into spoil is restricted, the water supply in the rooting zone of plants can be affected.

Information is needed on methods of improving infiltration of dispersed spoil materials. This study was conducted to evaluate the effects of tillage of the spoil surface, prior to placement of plant rooting material, on water movement into the spoil medium.

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Procedure

The study was conducted at the North American Coal Corporation Indian Head Mine near Zap, North Dakota. The experimental site was mined in 1971 and reshaped in 1973. Single plots were located on noncultivated, moldboard plowed and disked spoil materials with SAR of 37. Tillage treatments were imposed immediately preceding topsoil placement in July, 1975. Tillage treatment depths were approximately 4 and 6 inches on the disked and moldboard plowed plots, respectively. About 3.1 inches of precipitation fell on these plots prior to testing. The infiltration study was conducted in November, 1975.

A 10-foot square, watertight enclosure was constructed of lumber at each site. A trench, extending 12 inches into the spoil, was excavated at the perimeter of each plot. Two layers of 6 mil polyethylene sheeting were then placed in the trench. The soil material was backfilled and the wooden enclosure installed.

The plant rooting medium placed on the spoil was of sandy loam texture. Gravimetric water content at field capacity was determined to be approximately 15 per cent by the 1/3 atmosphere pressure plate method. Some characteristics of the topsoil and spoil materials are described in Table 1.

Table 1. Topsoil and Spoil Characteristics

Material	Texture[1]	SAR[2]	Bulk density g/cm$_3$	Per cent Sand	Silt	Clay
Topsoil	SL	3	1.5	55	26	19
Spoil	CL	37	1.5	31	38	31

[1]*SL - sandy loam; CL - clay loam*
[2]*When concentrations are expressed in milliequivalents per liter, SAR = Na/[(Ca + Mg)/2]$^{1/2}$*

Water was applied to the soil surface until the infiltration rate approached zero. Approximately 24 hours later, an additional application was made until rate of infiltration approached zero. Samples for gravimetric water content were taken immediately before and approximately 48 hours after the initial water application. These samples were collected at three points in each plot. Topsoil samples were taken in 3-inch increments except for the interval immediately above the spoil. Samples were collected in 3-inch increments from the spoil interface downward to a depth of 15 inches. Minor variations in topsoil depths occurred between treatments because establishment of uni-

form depths was not possible with the large earth-moving equipment employed.

Results and Discussion

Average standard deviations of 1 and 3 per cent were determined for gravimetric water contents of the topsoil and spoil samples, respectively. Data of water contents in the nontilled treatment are presented in Table 2. This information indicates that the topsoil apparently was still above field capacity 48 hours after the initial water application. Significant changes in water storage of the spoil medium were restricted to the 0- to 3-inch depth. Thus, the nontilled spoil interface appeared to restrict downward water movement. This is attributed to the high SAR of the spoil material.

Table 2. Water Content - Nontilled Site - Before and 48 Hours After Water Application.

Material	Depth, inches	Water content, % by weight[1]		
		After	Before	Change
Topsoil	0-3	23	12	11
	3-6	25	13	12
	6-9	24	13	11
	9-11	24	13	11
Spoil	0-3	28	14	14
	3-6	13	9	4
	6-9	14	12	2
	9-12	14	14	0
	12-15	16	14	2

[1]*Data are averages of three samples.*

Data presented in Table 3 were obtained from the moldboard plowed treatment. There was no significant change in water content of the spoil below the 0- to 3-inch depth. The overlying topsoil was near saturation 48 hours after water was applied as in the nontilled treatment. Water movement into the plowed spoil material below the 3-inch depth was not apparent.

Table 3. Water Content - Moldboard Plowed Site - Before and 48 Hours After Water Application.

Material	Depth, inches	Water content, % by weight[1]		
		After	Before	Change
Topsoil	0-3	25	11	14
	3-6	23	12	11
	6-8	25	17	8
Spoil	0-3	28	13	15
	3-6	19	14	5
	6-9	16	14	2
	9-12	18	14	4
	12-15	17	14	3

[1]*Data are averages of three samples.*

Water contents of the topsoil and spoil in the disked spoil treatment are shown in Table 4. A nearly saturated topsoil zone was present, just as existed on the nontilled and plowed treatments. But a substantial change in water content of the spoil occurred to a 6-inch depth and a slight increase was apparent at the 6- to 9-inch depth. Thus, disking appears to have increased infiltration to a greater depth than moldboard plowing.

Table 4. Water Content - Disked Site - Before and 48 Hours After Water Application.

Material	Depth, inches	Water content, % by weight[1]		
		After	Before	Change
Topsoil	0-3	26	10	16
	3-6	24	12	11
	6-0	25	10	15
	9-12	26	9	17
	12-13	24	7	17
Spoil	0-3	29	11	18
	3-6	27	11	16
	6-9	17	10	7
	9-12	15	12	3
	12-15	14	12	2

[1]*Data are averages of three samples.*

When the movement of gravitational water from the root zone is impeded by a layer of low permeability, soil aeration can be restricted and plant growth inhibited when saturated conditions exist. Increasing the thickness above the restrictive layer would be expected to lessen potential drainage difficulties.

The topsoil material alone must provide water needed for plant consumption use if buried spoil materials greatly restrict water flow. Research data are presently not available to define the exact topsoil depth that should be returned for optimum productivity.

Conclusions

Disking the spoil interface of high sodium adsorption ratio prior to topsoil placement significantly increased the depth of water penetration into the spoil by approximately three inches. No significant difference appeared in water storage between nontilled and moldboard plowed spoil materials. The underlying spoil on both the tilled and nontilled treatments greatly restricted downward water movement.

Reference

1. VanDerwalker, John G. 1975. **Effects of coal development in the northern Great Plains.** Northern Great Plains Resources Program. Summary Report. May.