RECLAMATION RESEARCH IN NORTH DAKOTA

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Lignite deposits underlie about 18 million acres of western North Dakota (Dalsted and Leistritz, 1974), almost 40 percent of the state. However, not all of this coal is economical to mine. Economically recoverable reserves are estimated at about 16 billion tons; these reserves underlie about one million acres. Some recent studies suggest that the amount of recoverable coal may actually be nearly 30 billion tons and underlie about 2 million acres. The mines currently operating or firmly committed to open by the mid-1980s (The Coteau Properties Mine north of Beulah) will disturb about 2,000 acres per year, and it is estimated that the total area currently committed to be mined is between 80 and 100 thousand acres. As the demand for energy increases and as economic conditions change, coal mining in North Dakota will undoubtedly increase. Some estimates suggest that North Dakota coal production will double or triple by the year 2000. It seems certain that surface mining in western North Dakota will continue to increase as the national demand for energy increases.

The people of North Dakota strongly support the mandatory restoration of surface-mined lands. Their concern resulted in the enactment of state reclamation laws several years before federal regulations were passed. As mining operations have continued to expand, public interest and concern for adequate reclamation have increased.

The North Dakota Agricltural Experiment Station and the USDA/ARS Northern Great Plains Research Center started reclamation research in the late 1960s. The early studies were concerned primarily with the chemical and physical characterization of overburden materials and grassland reestablishment on reclaimed areas. In 1974, North Dakota State University received a grant from the Old West Regional Commission for an expanded reclamation research program conducted by the Soils Department. Because of increasing public interest in reclamation and because of the need for a broader-based research program, the Land Reclamation Research Center (LRRC) was established July 1, 1981 as a branch of the Agricultural Experiment Station to conduct and coordinate NDSU research in all agriculturally-related areas of reclamation. Offices and laboratories are located at the USDA/ARS Northern Great Plains Research Center in Mandan. The USDA/ARS staff at Mandan is also conducting reclamation research; the NDSU and USDA groups work closely together for optimum efficiency.

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LRRC RESEARCH PROGRAM

The LRRC research program is an action-oriented program designed to provide guidelines for the optimum use of available soil and overburden materials so that our lands will be permanently restored for the best possible use, reclamation costs can be kept at a minimum consistent with the best possible reclamation, and the public mandate for the restoration of disturbed lands is met.

This program is developed with the assistance of an advisory committee composed of representatives from seven counties where coal mining is either underway or contemplated, from state agencies concerned with reclamation from the coal companies, and from the NDSU administrative staff. This committee meets periodically to discuss technical reclamation problems and to ensure that the LRRC program is directed to problems related to the most pressing research needs.

As stated by Melsted (1980), reclamation research has as its primary broad objective the return of the land to some level of agricultural production such that its productivity is "equal to or better" than its pre-mine level. At first this may appear easy. Just return the topsoil and subsoil to their original positions and productivity will be reestablished. In practice the problem is more complex.

First attempts to reclaim strip mined lands involved the revegetation of reshaped spoils. Initial results were not entirely satisfactory; productivity was not always restored to the pre-mine level (Power et al., 1974). The spoil materials derived from the overburden overlying the coal seams were found to be highly variable (Schroer, 1978), and the most important spoil characteristics determining reclamation potential were the sodium level and the clay content (Sandoval et al., 1973). High sodium levels in the spoil were the most critical single factor. Infiltration of water into the spoil is limited, and movement of water that does infiltrate is restricted. Plant roots cannot readily penetrate the spoil. On the other hand, when spoils are coarse-textured (high in sand and low in clay), the water-holding capacity is low and plant growth is restricted by lack of water.

To overcome these problems, topsoil and subsoil materials were replaced over the reshaped spoil. It was soon found that even 2 inches of topsoil over sodic spoil greatly enhanced plant establishment (Power et al., 1974). But the pre-mine productivity was not restored. In the next experiments, up to 12 inches of topsoil was applied (ARS/NDSU, 1977). In the beginning, both forage and crop yields with 12 inches of topsoil were good, occasionally approaching yields before mining. However, yields on reclaimed soil underlain by highly sodic spoil began to decrease after three or four years. This was found to be due to upward migration of sodium from the spoil into the overlying soil materials.

Further experiments were conducted in which more topsoil and subsoil were replaced. Over highly-sodic fine-textured spoils, crop yields increased as the replaced soil thickness increased to the 36 to 60 inch range; in over 90 percent of the cases, yields when 36 inches was replaced were equal to or greater than yields on similar undisturbed soils (Power et al., 1981). When the underlying spoil was fine-textured and only moderately or non-sodic, replacement of 24 to 30 inches of soil material gave good yields (Pole et al., 1979; Halvorson et al., 1980). But when the underlying spoil was non-sodic but coarse-textured (with a low water-holding capacity), more than 30 inches of replaced soil was needed for good yields (Halvorson et al., 1980; Halvorson, Melsted and Doll, 1982). Unpublished research results suggest that optimum depths of soil replacement over sodic spoils may be related to topographic location. More information is needed concerning vertical and lateral movement of sodium in reclaimed soils as affected by runoff from the higher topographic positions with corresponding runon and increased infiltration on the lower-lying positions.

The most limiting factor for crop production in western North Dakota is usually moisture. Even though the moisture levels in some newly reclaimed soils may not differ greatly from that on nearby undisturbed soils, plants are not able to efficiently utilize this water. For good root development, soils must have structural aggregates and must contain open spaces to allow air and water to enter and move downward. During mining and reclamation, this structure is disrupted and the soil materials are compacted. In a study of root development in reclaimed soils (Gilley, Schlenker and Doll, 1982), often no measurable roots were found in the spoil material for several inches. Small amounts of roots would then appear at various depths. This nonuniform type of root penetration could be explained by the nature of the spoil material. The spoil is characteristically heterogeneous, occurring in a variety of shapes and sizes. Roots would be expected to follow a very tortuous path through the soil medium, penetrating areas between spoil particles. The effects of this lack of structure on moisture levels and root development is one reason why plant growth is restricted for the first two or three years after reclamation. Research results indicate that these favorable soil properties begin to develop immediately after reclamation, but that several years are needed before optimum conditions are reached.

Moisture levels in the top 8 feet of reclaimed soils were measured at over 100 lcoations for eight years. Schroeder, Enz and Bauer (1981) evaluated soil moisture recharge during the nongrowing season. Recharge of soil water generally occurs from late fall and winter precipitation. Knowledge of how much water will be stored between November and April is a necessary reuqirement for evaluating probability of revegetation success for the coming year. A linear model has been devleoped to predict how much total soil water will be stored in the top 4 feet of the soil from late fall and winter precipitation. Sodium adsorption ratio and a relative factor describing the possibilty of runon or runoff were the most critical factors governing fall and winter water storage. Use of this model for the estimation of total storage water from late fall and winter precipitation will grealty enhance the chances of revegetation success for the coming season.

In a related study, Schroeder and Bauer (1982) measured changes in root zone water with a neutron moisture probe in access tubes to a depth of 8 feet in levelled mine spoils and nearby undisturbed grassland sites. From time of installation (summer, 1974) to November, 1981, total water content generally decreased. Water content of the 0 to 4 ft. (root-zone) depth never exceeded the total field capacity and the water content was frequently below the wilting point. Movement of water below 8 feet on either spoil or undisturbed sites did not appear to occur. Variation between monthly measurements was greater in the 0 to 4 ft. depth than in the 4 to 8 ft. depth. Changes in the 4 to 8 ft. depth appeared to occur more slowly. The water content of the native sites was generally higher than that of the spoil sites and tended to vary more both between sites and from month to month than did the water content of the levelled spoil sites. These differences between disturbed and undisturbed sites is attributed to disruption of soil structure and root channels and compaction by heavy machinery during the mining and reshaping of spoil materials.

Increases in soil moisture were never equal to the amount that fell in precipitation, even when evaporation and plant use were estimated. Differences between the total precipitation and the amount of water that entered the soil must have been due mostly to surface runoff. This is why it is so important to develop soil management systems that allow for increased water infiltration and to plan the post-mine topography to lower the amount of runoff and increase the amount of water that infiltrates into the soil. At the same time, enough runoff must be allowed for the collection of water in low-lying areas to provide for recharge of ground-water aquifers.

Numerous fertilizer experiments have been reported from experiments conducted on reclaimed soils (Bauer, Berg and Gould, 1978; Bauer, Nyren, Reichman,Gee and Gilley, 1978; Halvorson, Zimmerman and Melsted, 1981; and Bauer and Halvorson, 1982). Yield responses have been obtained for nitrogen and phosphorus at some locations. These results indicate that the soil test interpretations developed by the NDSU Soil Testing Laboratory for use on undisturbed soils are applicable to reclaimed soils. Furthermore, the application rates developed upon the basis of soil test levels also appear to be adequate for reclaimed soils. Consequently, no additional fertilizer research on reclaimed soils is anticipated at this time.

When the vegetative cover is removed during mining, the uncovered overburden, the spoil both before and after reshaping, and the replaced soil materials are all highly subject to erosion because of their disruption by the mining processes. The natural structure is disrupted, the rate of water infiltration is decreased, and runoff and erosion correspondingly increased. A number of research projects have been conducted using runoff plots and rainfall simulators to obtain data to predict runoff and sediment loss and develop methods to reduce erosion losses. These results can also be used to design post-mine landscapes that will result in optimum infiltration of rainfall and on which erosion losses can be kept to a minimum.

FUTURE DIRECTION OF RECLAMATION RESEARCH

Most of the past research has been directed to obtaining needed information to meet the requirements of current reclamation laws and regulations. Much of the future research must also be addressed to these immediate questions. More information is needed concerning optimum depth of replacement of soil materials as related to sodium levels and post-mine topography. Runoff and erosion need to be related to soil characteristics and topographic configuration so that improved management systems can be developed and sediment loss reduced. Rainfall and snowfall need to be more efficiently utilized. Definitive procedures need to be developed to evaluate reclamation success. The first objective of reclamation research has been and must continue to be the best possible reclamation of mined lands. But it is in the best interests of all concerned to do this at the lowest practical cost. Site-specific standards need to be developed which are based upon the characteristics of the underlying spoil and the quality of the soil materials available for respreading.

Research programs need to be initiated to study different possible post-mine land use patterns so that alternative choices can be given for reclamation planning. Post-mine topographies which result in optimum use of rainfall and snowfall and result in the best use of all available topsoil and subsoil materials need to be planned. Alternative post-mine land use plans can then be developed based upon the geologic characteristics of the reshaped spoil and the quality of available soil materials. Respreading of available soil material uniformly over the entire area to be reclaimed may not result in the best post-mine land use. Perhaps part of the area should receive deeper replaced soil material than was originally present before mining, making it suitable for intensive cropping. The remaining part of the land would receive less respread soil for a less intensive use. Should water impoundments be designed when feasible for irrigating the area designed for intensive use? If land can be reclaimed to its premine productive level, but if an alternative reclamation plan can lead to a much higher post-mine productive level, but at a higher reclamation cost, which plan should be followed?

North Dakota can be justly proud of its land reclamation program. The economy of the state is largely based upon its agriculture. And the maintenance of this agricultural base in turn depends upon the wise use, management, and conservation of the soil. Research has shown that even after the drastic disturbance caused by strip-mining, soils can be restored to their original level of productivity, and that increased productivity is possible in some cases. However, post-mine reclamation planning is in its infancy. Coal will be mined in North Dakota well into the next century. The opportunity exists to significantly improve the agricultural base in western North Dakota.

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