COMPARATIVE EVALUATION OF PRODUCTIVITY OF PRIME AND NONPRIME SOILS

AN AMENDED PROPOSAL
SUBMITTED TO THE
LIGNITE RESEARCH COUNCIL

OF THE
NORTH DAKOTA INDUSTRIAL COMMISSION

PRINCIPAL INVESTIGATOR

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SUMMARY

Current surface coal mineland reclamation regulations require separate handling of prime and nonprime soils. The proportion of soils which qualify as prime due to their location in a landscape unit of west central North Dakota is low, and hence the separate handling is costly. Previous research on comparisons of prime and nonprime soil productivity between undisturbed and reclaimed lands have not been comprehensive and conclusive due mostly to comparisons based only on biological yield. Past research has also suggested that a better measure of the productivity of a particular soil at a given topographic location is to measure soil properties which affect potential yield. The objective of this study is to systematically monitor both yield and the soil properties comparatively between prime and nonprime soils. This will be accomplished in three tasks. Task I will compile and analyze data from previous and ongoing prime/nonprime soil productivity research. Task II will establish experimental plots of prime/ and nonprime topsoil at a given topographic and microclimate setting and monitor yield and soil and environmental factors that affect yield. Task III will summarize information from Task I and Task II and analyze the data to compare actual as well as potential yields between prime and nonprime soils. This research is expected to help answer the prime and nonprime productivity issues and generate a more objective tool to evaluate reclamation success.

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OBJECTIVES

1. Compare the productivity of undisturbed prime and nonprime soils to the productivity of reclaimed prime and nonprime soils.

2. Use prime and nonprime soil properties to predict potential productivity of reclaimed soils.

Field studies using prime and nonprime soils should help to determine if segregation of prime and nonprime topsoil is necessary. If topsoil segregation is not necessary, savings to North Dakota coal companies could be substantial.

INTRODUCTION

Current federal and state regulations require separate handling of prime and nonprime topsoils. According to the present interpretation of prime farmland criteria, soils designated prime in the ustic moisture zone of North Dakota qualify because of landscape position. Most of these soils occur on nearly level or concave portions of the landscape and receive runoff from adjacent soils in a higher position which do not meet prime farmland criteria. Prime soils are therefore, the product of microclimate and local surface and root zone hydrology rather than macroclimate or parent material.

In western North Dakota, availability of water is the most dominant factor controlling crop yields. Under conditions of limited rainfall, which is the general rule, the yield potential of prime land may not be significantly different from the yield potential of nonprime land. If the differences in the productive capabilities of prime and nonprime soils are the results of moisture differences due to topographic location rather than to differences in the properties of soil materials, then the currently required separate removal and placement of topsoil materials is unwarranted. In addition, higher overall productivity of reclaimed land may be attained by replacing available soil materials uniformly on an area reshaped to the most effective topographic configuration. The purpose of this project is to generate scientifically sound data to either support or reject this hypothesis.

Success of reclamation on crop land following stripmining is determined from crop yields on the reclaimed land. In the semi-arid west the bonding period between the reclamation of a mined area and the final determination of reclamation success is ten years. Yield measurements for the last two years of the bonding period on nonprime farmland and the last three years of the bonding period on prime farmland are required to evaluate reclamation success. The yields from reclaimed land are commonly compared to a similar undisturbed reference site or else are compared to predicted yields based on National Cooperative Soil Survey yield potentials. Inherent problems occur with either one of these systems. Undisturbed reference areas are not directly comparable to reclaimed land because of differences due to disturbance during mining and mixing of soil materials. Additional variations can occur due to precipitation, disease, and insect infestation differences between undisturbed and reclaimed locations. Comparisons based on National Cooperative Soil Survey yield potentials are also subject to these same problems.

The central flaw using crop yields to measure reclamation success is that yields are a measure of production from a parcel of land in a given year under a given set of environmental conditions rather than a measure of the potential productivity of

the land. Thus, reclamation success standards should be based on the potential productivity of a soil. Routinely measured soil physical and chemical properties may possibly be used to predict potential soil productivity. Measured yearly production would then be a function of the potential productivity of the soil. Using soil properties to estimate potential productivity eliminates many of the problems due to variations in precipitation, plant diseases and insect infestation. This approach may facilitate objective evaluation of reclamation success and recommendation of final bond release in a shorter time frame than the ten years stipulated by law.

SCIENTIFIC DISCUSSION

Crop production data from reclaimed cropland provide valuable information for determining reclamation success. However, research has shown that there are many complications in comparing these data to other standards. One method of determining reclamation success utilizes predicted yields based on National Cooperative Soil Survey yield potentials. The North Dakota Public Service Commission uses such a system to evaluate reclamation success on cropland. Erickson (1985) reported on a method of evaluating rangeland reclamation success from adjusted Soil Conservation Service Technical Guides in conjunction with Order III Soil Surveys. Although some success has been achieved in using these methods, the interpretations of results are impaired by the influence of topography, environment, management, and pests on yields.

Problems also exist when using reference areas with varying topography for yield comparisons. In one study, summarized by Doll, et al. (1984), subsoil was respread in the shape of a double wedge. Yields were influenced considerably by the topographic position and the slope aspect. Wollenhaupt and Richardson (1982) found that yields were influenced by microtopographic differences within the plots. In this same study, yields from undisturbed reference plots were compared to yields from the reconstructed trench plots (Halvorson, et al. 1986). Average yields from the trench plots were greater than or equal to yields on the reference plots in two years out of five while in the other three years they were less. Although the reference plots were located on adjacent similar soil materials and topographic locations, reclamation success would have been either proved or disproved depending on which year or years crop yields were measured. Pole, et al. (1979) collected data over a four-year period from a reclaimed site and found that crop yields increased with time following reclamation due apparently to the gradual establishment of a more favorable moisture regime. Addition of these results to the problems of potential differences due to other environmental and management factors increases the probability of misinterpreting yields from reclaimed land compared to a reference site.

From the results of a three-year experiment comparing crop yields from reclaimed and undisturbed prime and nonprime soils located at two different mines, Schroeder and Doll (1984) concluded that, due to rainfall differences and insect and small animal damage on sites isolated from other cropped areas, precise evaluation of soil factors contributing to yield differences was not possible. Even though these plots were designed for statistical comparisons, and statistically significant differences were obtained, no consistent trends were obtained. Over the three-year period, the relation of yields on reclaimed soils to those on undisturbed soils were

inconsistent; in some cases they were significantly higher, in others significantly lower, and sometimes not different.

Research was performed in a controlled greenhouse experiment comparing wheat yields from prime (Bowbells) and nonprime (Williams) soils from the same soil association (Carter and Doll, 1983). Two successive crops were grown under optimum conditions using the same soil materials. In the first crop, yields from the prime soil were significantly higher than from the nonprime soil. The higher organic matter content of the prime soil may have resulted in better aeration for crop growth. The structure of the soil samples was severely disrupted during the process of drying and screening. However, in the second crop, yield differences between the prime and nonprime soil were not apparent. Visual observations of the soil materials during repotting for the second crop indicated that the physical structure of the soils was appreciably better than when the first crop was planted. These results indicate that yields on reclaimed prime soils may initially be higher than yields on reclaimed nonprime soils. However, after soil structures have been reestablished, yields between the soils would not be expected to differ. Carter and Doll (1983) recommended the use of field experiments to adequately evaluate productivity differences among both disturbed and undisturbed prime and nonprime soils.

The capacity of a soil to produce a potential yield depends on soil parameters which can be measured quantitatively. Research at the Land Reclamation Research Center has shed new light on the measurement and importance of using soil parameters for the determination of reclamation success. Carter, et al. (1987) reported that "in situ" soil properties such as bulk density, macropore space, and hydraulic conductivity are the soil parameters most severely disrupted during mining and reclamation. In continued studies, Carter (1991) found that average values of soil chemical properties, texture, and calculated percents of pore sizes were not significantly different between prime and nonprime soils located in a 10 ha site. Bulk densities at all measured depths were generally higher (not significant) from the prime soils during all four years of the study. Surface infiltration rates, measured in 1990, were significantly higher from the nonprime soil which indicated the existence of greater or larger continuous macropores than in the prime soil. These results indicated the need for more investigation into the properties of reclaimed and undisturbed prime and nonprime soils and the effects of these properties on soil productivity.

PROPOSED WORK

The overall objective of this research will be to determine the influence of soil materials on the productivity of prime and nonprime soils in undisturbed and reclaimed settings. The objectives will be accomplished using three separate tasks:

Task 1: Sites on reclaimed land have been established and monitored for yield for the past five years. Yields from these sites will be measured again in the coming years to evaluate effect of topographic positions in a reclaimed landscape. These sites include three soils on a topographic sequence at the BNI mine at Center, N D and a site at the Falkirk mine near Underwood, North Dakota. In addition, an undisturbed micro-catchment at the Falkirk mine will also be monitored for wheat yields. Information from this undisturbed site should provide data that can be used to compare with reclaimed sites.

Task II: Plots will be established at two different locations on reclaimed land. Topsoil material from prime and nonprime soils will be transplanted to the site and respread on separate level plots away from terrain which may supply runon water. Wheat will be grown on these test plots and yield measurements will be taken. In addition, the soils will be monitored for SAR, EC, saturation percentage, soil moisture throughout the growing season, texture, bulk density, hydraulic conductivity, and water holding capacity. Precipitation will be monitored at the sites. Plant parameters which will be monitored include rooting depth, grain yield, degree of weed and insect infestations, and plant disease problems.

Task III: The data obtained from Tasks I and II will be compiled and those factors which have important effects on yield will be determined statistically. These factors will be developed into a model which will allow for the prediction of the productivity of prime and nonprime topsoils on reclaimed land.

BUDGET

Year 1		
	Industrial Commission	LRRC
Salaries		
Scientists	24,000	20,000
Technicians	4,000	15,200
Fringe Benefits	7,560	9,504
Operating		
Supplies	3,000	1,000
Travel	2,000	-0-
Total Direct Costs	40,560	45,704
Indirect Costs (22%)	8,923	10,054
TOTAL	**$49,483**	**$55,758**

In kind contribution of ND Lignite Industry for equipment use and time for the construction of field plots is estimated to be $5,000. This is based on a projected cost of $100 per hour and 50 hours of equipment time. This contribution is subject to approval by the coal companies of the final details of the project.

BUDGET

Year 2		
	Industrial Commission	**LRRC**
Salaries		
Scientists	24,000	10,000
Technicians		18,000
Fringe Benefits	6,480	7,560
Operating		
Supplies	3,000	1,000
Travel	2,000	-0-
Total Direct Costs	35,480	36,560
Indirect Costs (22%)	7,806	8,043
TOTAL	**$43,286**	**$44,603**

BUDGET

Year 3		
	Industrial Commission	**LRRC**
Salaries		
Scientists	24,000	10,000
Technicians		18,000
Fringe Benefits	6,480	7,560
Operating		
Supplies	3,000	1,000
Travel	2,000	-0-
Total Direct Costs	35,480	36,560
Indirect Costs (22%)	7,806	8,043
TOTAL	**$43,286**	**$44,603**

OTHER SUPPORT RELATED TO THE PROPOSED WORK

The Land Reclamation Research Center (LRRC) currently receives funding from the North Dakota Legislature on a biennial basis to conduct research on the reclamation of land drastically disturbed by mining. This money along with outside grants currently supports the research of five scientists, five technicians, a secretary and temporary help.

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