PRODUCTIVITY OF PRIME AND NONPRIME TOPSOIL RECLAIMED IN EQUIVALENT TOPOGRAPHIC POSITIONS

by

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Abstract. Coal companies in North Dakota are required to separate primeland topsoil from non-primeland topsoil before mining. Following mining, the prime topsoil must be replaced in a prime location and the nonprime topsoil in a nonprime location. This separate handling of these materials is expensive and may be unnecessary. This research was conducted to (1) compare the productivity of prime and nonprime topsoil materials placed side by side in different topographic positions, and (2) to determine whether the separate handling of prime and nonprime topsoil is necessary. Plots were established at two different sites. The selected topsoil materials from Bowbells (prime soil), Williams and Zahl (nonprime soils), were transported to the reclaimed side of the pit and placed on separate plots adjacent to each other in the same topographic position. Plots were constructed on both prime and nonprime topographic positions and at the Coteau site two different topsoil depths were evaluated. In the first year of the study, dry matter yields and grain yields were lower on Zahl than on Bowbells or Williams topsoils. These differences could be accounted for by differences in initial soil moisture levels. The year 1993 was a wet year and the crop had sufficient available moisture in the profile throughout the season in the top 0 to 60 cm depth. At both sites there were no significant grain yield differences between prime and nonprime soils. No significant grain yield differences were observed between the topographic positions in the landscape. In 1994, at the Falkirk site no significant differences in yield could be determined between the three different soil series. At the Coteau site the wheat grown on the Zahl soil yielded slightly less than that growing on the Williams and Bowbells soils. As would be expected in a year when moisture was short, topographic position made a difference in yield. Depth of topsoil made no difference in yield for 1994.

Additional Key Words: mining, soil moisture, landscape

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 positions 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 primeland may not be significantly different from the yield potential of nonprime land. If the differences in the productivity

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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.

In a greenhouse study, yields on reclaimed prime soils were initially higher than on reclaimed nonprime soils (Carter and Doll, 1983). After soil structure had been reestablished yields between the soils were not different.

Carter and Doll, (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 25 acre site. Bulk densities at all measured depths were generally higher from prime soils than nonprime during all four years of the study.

Topography has been shown to influence crop yields on land reclaimed following mining in North Dakota (Doll et al., 1984). A method to quantify the relationship between the topographic redistribution of water and wheat yields was developed (Halvorson and Doll, 1991).

This study was undertaken to compare the productivity of prime and nonprime topsoil materials when placed side by side in different topographic positions.

Methods and Materials

One site was selected at the Coteau Properties Freedom Mine. Two plot areas were selected which would be reclaimed as rangeland with a topsoil depth of about eight inches. One of these was located on a hilltop to simulate a nonprime topographic position and the other was nearby on a toeslope position to simulate a prime topographic position. Two more plot areas were selected nearby which would be reclaimed as cropland with a topsoil depth of 15 inches. One site was on a hilltop and one was on a toeslope position to simulate nonprime and prime topographic positions, respectively. The other location was at the Falkirk Mine. Only two plot areas were selected at this location, one in a prime topographic position and the other in a nonprime topographic position which were reclaimed with a cropland soil depth of 15 inches.

Two nonprime soils used in this study were: the Zahl loam series (fine-loamy, mixed Entic Haploboroll) which is found on hilltops and shoulder positions and the Williams loam series (fine-loamy, mixed Typic Argiboroll) which is located on sideslopes and hilltops. The one prime soil used was the Bowbells loam series (fine-loamy mixed Pachic Haploboroll) which is located on footslopes and toeslopes.

Subsoil from each soil series was not segregated. Mixed subsoil was laid down at uniform depths on graded spoil material. Scrapers were used to transport the subsoil and topsoil to the plot areas. Topsoil from the Williams, Bowbells and Zahl soil series was placed on the plots at a depth of eight inches on rangeland plots and 15 inches on cropland and were replicated three times at each plot area. The plots were carefully leveled and smoothed with a bulldozer. The plots were disked and seeded to Stoa spring wheat (Triticum aestivum L.) on June 23, 1992. The plots at the Falkirk location were not completed until August, 1992 and therefore, were not planted for the first time until 1993. Soil samples from each plot were taken from each plot using recommended soil test procedures. Plots were fertilized with N and P for a 50 bushel per acre yield. Plots were seeded at the rate of one million live seeds per acre.

The plots were harvested by hand cutting three square meters from each plot, drying the bundles and then threshing the wheat in a small thresher. Yield data from three years, 1992-1994, is presented. Statistical comparisons of the data were made within each years' data using analysis of variance and least significant difference (.05) comparisons. Least significant differences are for interaction means for all treatments at a site for a given year.

Results and Discussion

In 1992 wheat yields were very low because of the very late planting date at the Coteau site (Table 1). There were no significant differences between prime and nonprime topographic positions and no significant differences between cropland and rangeland soil depths. On the cropland soil depth wheat yields on the Zahl soil were significantly lower than on the Williams or Bowbells soils. This is mainly the result of a lower soil moisture content in the Zahl topsoil. Very little precipitation fell on these soils in the weeks prior to plot construction. The topsoil was removed from the surface five inches of the Zahl soil and the surface 15 inches and 25 inches from the Williams and Bowbells soils respectively, for plot construction. Since the surface was very dry and more moisture was available deeper in the profile, the topsoil material from the Zahl soil was the driest of the three soils. A plot of wheat grain yield versus initial soil moisture in the surface foot show the high correlation (r^2) = 0.71 between these two factors (Figure 1).

In 1993, growing season precipitation was 13.0 and 14.4 inches at the Coteau and Falkirk sites respectively, which was much above the average of 6.9 and 7.7 inches respectively. There were in fact, problems with minor flooding and water standing on the plots. In particular the prime topographic position at the Falkirk site had lower yields than the non-prime topographic position due to problems with too much water (Table 2). Wheat yields on the Bowbells and Williams soils on the prime topographic position were actually lower than on the Zahl soil. No yield differences between soils were noted on the nonprime topographic position. At the Coteau site in 1993 (Table 1) no statistically significant differences occurred between prime and nonprime topographic locations or between the three different soils tested. Wheat yields were significantly lower on the rangeland soil depth than on the cropland soil depth.

Table 1. Wheat grain yields (bu/ac) at the Coteau location, 1992-1994.

	Topographic Landscape Position	
Soil Series	**Prime**	**Nonprime**
	Cropland - 1992	
Bowbells	9	10
Williams	8	9
Zahl	5	2
	Rangeland - 1992	
Bowbells	11	10
Williams	11	9
Zahl	9	8
LSD (0.5) = 3		
	Cropland - 1993	
Bowbells	52	52
Williams	46	50
Zahl	53	49
	Rangeland - 1993	
Bowbells	41	42
Williams	43	40
Zahl	44	39
LSD (0.5) = NS		
	Cropland - 1994	
Bowbells	30	31
Williams	29	26
Zahl	29	22
	Rangeland - 1994	
Bowbells	35	20
Williams	40	19
Zahl	29	18
LSD (0.5) = 6		

Table 2. Wheat grain yields (bu/ac) at the Falkirk location, 1993-1994.		
	Landscape Position	
Soil Series	Prime	Nonprime
	bu/ac	
	1993	
Bowbells	36	51
Williams	37	49
Zahl	45	51
LSD (.05) =8		
	1994	
Bowbells	34	26
Williams	39	32
Zahl	34	27
LSD (.05) = 11		

Wheat yields were somewhat lower in 1994 due to an extended period during the middle of the growing season with very little precipitation. At the Falkirk site no significant differences in yield between the three soils occurred (Table 2). Yields from the nonprime topographic position were significantly lower than yields from the prime topographic position. At the Coteau site in 1994 no differences in wheat yields occurred between cropland and rangeland soil depth (Table 1). The wheat yield on nonprime topographic positions was lower than on prime topographic positions. On the cropland soil depth in a nonprime topographic setting wheat yields were lower on the Zahl soil than on the Bowbells. On the rangeland soil depth in a prime topographic setting yields of the Williams soil were higher than the Zahl soil, but no significant differences between yields on the Zahl and the Bowbells soil occurred. Differences between the three soils did not occur on the other two plot areas at the Coteau mine.

Conclusions

Differences did occur in the treatments in the three years of the study. The Zahl soil yielded less in 1992 than the Bowbells soil, but this could be explained by the difference in initial soil moisture content. The Bowbells soil also yielded higher than the Zahl soil on the cropland soil depth in a nonprime topographic position in 1994. On the other hand in 1993 the Zahl soil yielded higher than Bowbells in a prime topographic position at the Falkirk location. Otherwise, the wheat yields from the three different soils were statistically equivalent. Overall, this is good evidence that the topsoil material itself from these three soils is of equal productivity.

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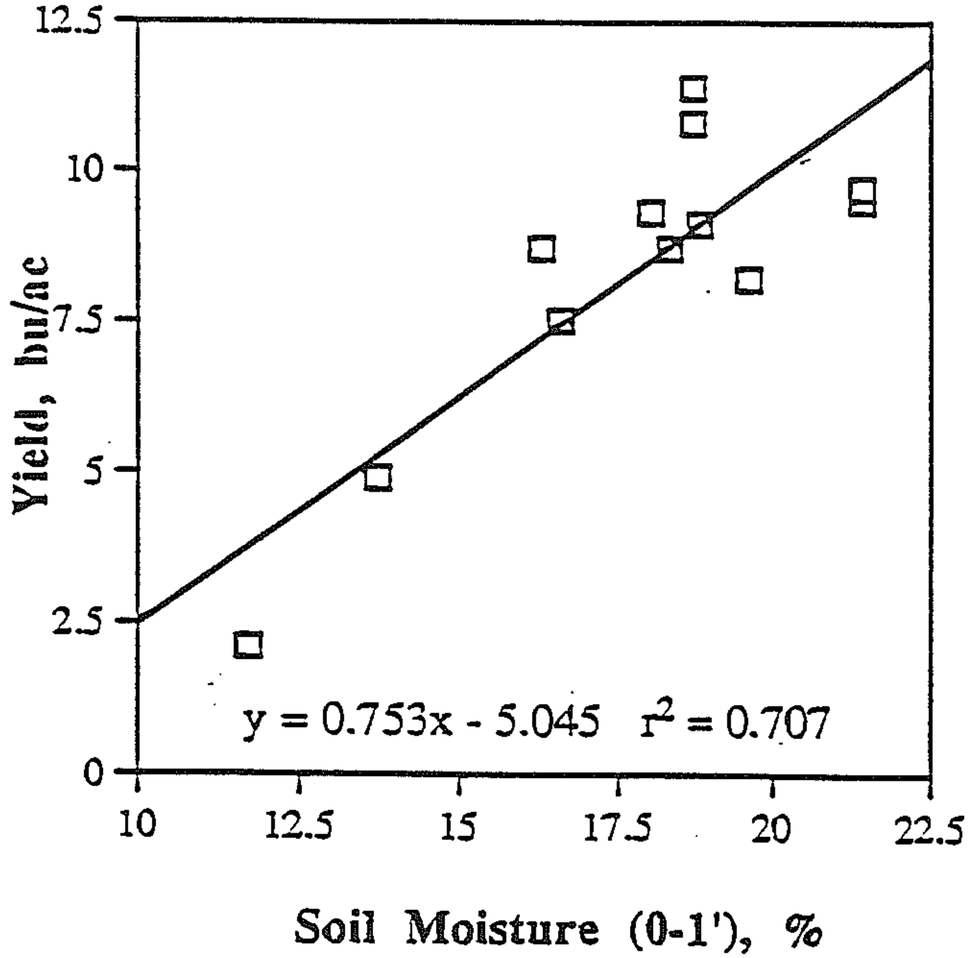

Figure. 1. The relationship between initial soil moisture at the 0-1 foot depth and grain yield in 1992 at the Coteau site.