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THE EFFECTS OF HERBAGE REMOVAL ON THE SOIL RESTORATION PROCESS IN THE RECLAMATION OF SURFACE MINED SPOIL

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ABSTRACT

A study was conducted at the Captain Mine, Arch of Illinois, Inc., Percy, Illinois on a Darmstadt soil series (fine-silty, mixed, mesic Abbic Natraqualf) to determine the effects of grazing, hay removal, and no hay removal of alfalfa (*Medicago sativa* L.) on a reclaimed surface mined B-horizon, loess, and glacial till mixture on the soil restoration process. Also, the performance of beef animals grazing alfalfa and hay yields on reclaimed surface mined B-horizon, loess, and glacial till soil mixture was evaluated. Economic returns from beef production and alfalfa production from strip mine spoil were very similar to those found in southern Illinois. Hay removal and grazing appear to be viable alternatives to the no hay removal treatment for the restoration of strip mined land. Although the soil restoration process was somewhat slower than the no hay removal as determined by reduced ($P < .05$) organic matter percentage, the economic returns from grazing or hay removal could be justified. The decision whether to produce alfalfa hay or beef on reclaimed surface mined spoil lies with the individual producer.

INTRODUCTION

Increasing demands for food and energy make it imperative that systems be developed to extract coal and reclaim farmland without reduction in the food producing potential while employing the most efficient and economical reclamation procedures. Past reclamation techniques for returning mined prime farmlands to intensive crop production have not been adequate. From the standpoint of reclamation methods and economics, two opposing views arise: (1) improper reclamation techniques result in low food producing potential of the stripmined farmland and (2) unnecessary mining operations needlessly increase costs reflecting higher energy costs to consumers.

Loess and glacial till are two major soil parent materials underlying the B-horizon of the weathered soils in southern Illinois. They have properties that are generally as good or better suited for rooting media than the B-horizon. Another alternative rooting medium is the mixing of the B-horizon with the underlying loess and glacial till by the bucket wheel excavator. This rooting medium does not have an organic matter content comparable to the uneroded A-horizon. However, this problem may be resolved by growing an "organic building" sod crop. The "organic building" sod crop provides economic returns by utilizing the sod during the reclamation process for grazing cattle or for hay.

Barnhisel (1977) reported that much has been postulated regarding the benefits of topsoiling in reclamation. Most likely there are many areas in the United States in which topsoiling would be beneficial, but in other areas, such as southern Illinois, southern Indiana and especially western Kentucky, the available topsoil and B-horizon material may have physical and chemical properties less desirable than geologic materials. Plass (1978) stated that topsoil replacement was of questionable value in Appalachia which has shallow, infertile soils and steep slopes.

It has been shown that soil formation is accelerated by using forage grass and legume sod crops (Carreker et al., 1968; Jones et al., 1975). Additionally, the use of a B-horizon and loess and glacial till mixture as a rooting medium together with a sod crop to enhance the organic matter buildup may be a viable alternative to B-horizon and topsoil replacement. When using a sod building crop during the soil restoration process, the land may not provide optimum economic returns. However, if the sod building crop is utilized as pasture for beef cattle production or as hay it should provide some economic returns with little disruption of the soil restoration processes for subsequent row crop production.

McCormack (1974) noted that the destruction of compact soil layers, apt to impede water movement and root growth, has sometimes led to improvement of the soil environment for plant growth after mining. Grandt (1978) stated that newly mined land should not be immediately planted to row crops but to a grass-legume mixture first. During this time, the soil's physical, chemical and biological properties will stabilize, thus allowing for the successful future cultivation of row crops.

A study of yearling steer performance on reclaimed and non-mined rangeland revealed that productivity on the reclaimed site was comparable to that on nonmined land (Hoffman et al., (1981). Baker et al., (1976) measured the productivity of sericea lespedeza (*Lespedeza cuneata* G. Con.) and 'Kentucky 31' fescue (*Festuca arundinacea* Shreb.) as forage for cow-calf herds. Over a three-year period average daily gains of suckling calves were .90 kg which resulted in total gains of 180 kg per calf during grazing seasons of 200 days duration. From this work it was concluded that satisfactory and economical beef calf gains could be obtained on surface mined land reclaimed with 'Kentucky 31' fescue and sericea lespedeza.

In Illinois and surrounding states, a large amount of land has been or will be reclaimed following surface mining. While beef and/or hay production are possible alternatives for restoring the production potential of surface-mined land, their effect on the restoration process has not been fully established.

The objectives of this study were to determine the effects of grazing, hay removal, and no hay removal of alfalfa (*Medicago sativa* L.) on a reclaimed surface mined B-horizon, loess and glacial till mixture on the soil restoration process and to assess the performance of beef animals grazing alfalfa as well as hay yields on reclaimed surface mined B-horizon, loess and glacial till soil mixture.

MATERIALS AND METHODS

This study was conducted at the Captain Mine, Arch of Illinois, Inc., Percy, Illinois, on a Darmstadt soil series (fine-silty, mixed mesic Abbic Natraqualf). The research site was reconstructed by the bucket wheel excavator with a mixture of B-horizon, loess, and glacial till (no topsoil replacement) followed by revegetation with alfalfa (*Medicago sativa* L.) 20 kg/hectare in 1982. Data collection began in May of 1983 and concluded in the fall of 1984 including two separate growing seasons. Soil samples for all treatments were analyzed for pH, phosphorus and potassium. Deficiencies were corrected according to soil test recommendations at time of alfalfa seeding. Maintenance P and K were added for each of the grazing seasons.

The restoration rates of three management systems were measured—grazing, hay removal and no hay removal. For grazing, four 1/2 hectare paddocks were used for the grazing portion of this study. Paddocks were rotationally grazed by yearling crossbred beef heifers of uniform weight and age. Prior to the study, cattle were confined to a feedlot and conditioned to protein blocks containing the bloat inhibiting chemical poloxalene. All heifers were vaccinated, dewormed and ear tagged for fly control. All cattle were weighed individually and reweighed after a 24-hour period. The weights were averaged together to establish a more uniform weight.

A "put-and-take" stocking system was used to adjust animal numbers beyond or below the initial stocking rate to maintain relatively uniform grazing pressure on the alfalfa and to allow for at least a 30-day rest period on each paddock. Stocking rates ranged from 0.22 to 0.25 ha/heifer during the 1983 season. This was largely due to low rainfall in July and August in 1983 and July 1984.

Cattle were allowed to graze the alfalfa in the first paddock to a height of approximately 7.5 cm. Cattle were then moved into the adjacent paddock (#2) and the alfalfa was grazed to the 7.5 cm height. The cattle were weighed and average daily gains recorded. While paddocks 1 and 2 were being grazed, paddocks 3 and 4 were mechanically harvested and allowed three weeks for regrowth. This was done in order to establish a similar maturity as to that of paddocks 1 and 2. After the three-week regrowth period, paddocks 3 and 4 were rotationally grazed to the 7.5 cm height. Cattle were then moved back to the first paddock where the rotation was repeated.

Grazing was terminated by September 15 of each year to allow the alfalfa to accumulate a supply of nutrients in the root system. Shade structures and water were provided at all times. Bloat inhibiting blocks occupied three locations in the grazed paddock and were fed ad libitum.

The hay removal treatment consisted of eight hay plots located adjacent to the paddocks. A 1 x 6 m swath was harvested from each of the 2 x 8 m hay plots at the first flower to one-tenth bloom stage with a 1 m width sickle mower. Hay yields were calculated on a dry matter per hectare basis. Alfalfa herbage was analyzed for crude protein, neutral detergent fiber, acid detergent fiber, ether extract and ash using methods outlined by the Association of Official Agriculture Chemists (A.O.A.C. 1980).

The no hay removal treatment consisted of eight alfalfa plots, 2 x 6 m in size adjacent to the alfalfa hay removal plots. Soil samples from all three treatments were analyzed for organic matter (Walkley-Black method), bulk density or g/cm^3 (Core method) and soil texture (hydrometer method). The procedures for these analyses were described by Scheck et al. (1978).

Six core samples were taken from each of the four paddocks for soil physical analyses. Soil samples were taken from each paddock for measurement of bulk density and organic matter content. One core sample and one soil sample were taken from each of the eight alfalfa hay removal plots and the eight alfalfa no hay removal plots in 1983 and 1984 and analyzed for bulk density and organic matter content. All core samples and soil samples came from the top 30 cm of soil. In addition to the 0-30 cm depth surface core sampling, 15 turbo soil core samples were taken from the center of the 30-60, 60-90 and 90-120 cm depths for bulk density measurements. These measurements were replicated four times at four different locations. The data were statistically analyzed by two-way analysis of variance and Duncan's new multiple range test was used to evaluate differences among treatments (Steel and Torrie, 1980). All statistical procedures were computerized using the Statistical Analysis System (SAS, 1982).

RESULTS AND DISCUSSION

Soil bulk densities and organic matter contents for paddocks, hay removal and no hay removal were determined to characterize the effects on soil restoration with time. Bulk density changes among the different treatments were not significantly different for the years 1983 or 1984 (Table 1). Mean bulk density values across all treatments for 1983 and 1984 were 1.61 gm/cm^3 and 1.63 gm/cm^3, respectively. The no hay removal treatment had the lowest bulk density. Organic matter additions generally lower the soil bulk density. It is postulated that the no hay removal treatment would have a significantly lower bulk density over a period of years as the top growth of the alfalfa adds more organic matter to the soil than the other treatments. Grazing had little effect on the soil bulk density for the 1983 and 1984 grazing years. Cattle grazing would tend to increase soil bulk density and the added manure from the grazing cattle would tend to decrease bulk density. The bulk density measurements for 1983 and 1984 indicate that these two effects are about equal. The bulk density data for all treatments shows that the hay removal and grazing treatments are viable alternatives to the no hay removal treatment for stripmine soil restoration.

Organic matter content for the different soil restoration treatments for 1983 and 1984 are given in Table 1. There was a notable increase in organic matter content for all treatments between years. The mean organic values across all treatments in 1983 was .48%, whereas, in 1984 it was .85%. The no hay removal treatment in 1984 was significantly higher in organic matter content than the hay removal treatment. The increased organic matter content for all treatments indicates that the hay removal and grazing treatments are also viable alternatives compared to the no hay removal treatment for stripmine soil restoration. However, it is postulated that the time required to reach the same level of restoration for hay removal would be somewhat longer than for the grazing. The manure from the grazing cattle would account for this difference.

The bulk density measurements for the 30 cm intervals from 30-120 cm depth are shown in Table 2. Bulk density increased for each 30 cm depth interval which is attributed mostly to soil settling from the weight of the above soil and probably some compaction from the heavy equipment and soil moisture content at the time of the reclamation.

The soil texture, the relative percentages of sand, silt and clay, are given in Table 2. The textural class of the mined site is a clay loam for 0-120 cm depth, whereas, the premined soil had a silt loam subsurface and a silty clay surface. The surface soil of the mined soil is appreciably heavier than the unmined soil and subsoil of the mined soil is a little lighter than the unmined subsoil.

The results of the grazing study for 1983 and 1984 are presented in Table 3. In addition to the animal production, approximately 3100 kg of alfalfa was removed each year from the paddock as trimmings. Hay production was 4800 and 6700 kg/ha for 1983 and 1984 seasons, respectively (Table 4). The increased alfalfa production for 1984 could have been the result of increased rainfall during the grazing season. The quality of the hay produced for both years was comparable to alfalfa in early bloom (IFN 1-00-059). Variability in protein content was due to stage of maturity at cutting (Table 4). The protein content in alfalfa tends to decline as it matures. Alfalfa was harvested at the full-bloom stage of maturity in 1983, whereas in 1984 it was harvested at an earlier stage (1/10 bloom). In terms of economic returns, one could utilize reclaimed surface mined spoil for either hay or animal production. However, the organic matter addition to the soil from grazing animals is an important consideration over the hay removal treatment.

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Table 1. Bulk density and organic matter content (0-30 cm depth) for treatments on reclaimed surface mined spoil at Captain Mine, Percy, Illinois.

Treatments	Bulk Density	Organic Matter
	gm/cm^3	%
1983		
Paddocks	1.64	0.44
Hay removal	1.61	0.46
No hay removal	1.58	0.48
1984		
Paddocks	1.65	0.85
Hay removal	1.65	0.78*
No hay removal	1.59	0.92*

*Means within a column for organic matter in 1984 differ (P<.05).

Table 2. Mean soil density and texture for the reclaimed surface-mined spoil at Captain Mine, Percy, Illinois.

	Bulk Density
Sample depth, cm	gm/cm^3
30-60	1.64
60-90	1.69
90-120	1.74
	Texture
	%
Sand	19.2
Silt	45.3
Clay	35.5

Table 3. Cattle Performance on Paddocks at Captain Mine, Percy, Illinois.

Year	Days on Paddock	Animal Days	Average Daily Gain (kg)	Animal Production kg/ha
1983	85	509	0.55	282
1984	90	840	0.46	390

Table 4. Analysis and production of alfalfa forage collected from hay removal plots on reclaimed surface mined spoil at the Captain Mine, Percy, Illinois, and compared to alfalfa early bloom (IFN 1-00-059).

Item	Dry Matter	Crude Protein	Neutral Detergent Fiber	Acid Detergent Fiber	Ether Extract	Ash	Yield
	%	%	%	%	%	%	kg/ha
		Dry Matter Basis					
Alfalfa IFN 1-00-059	90	18.0	—	31.0	3.0	9.6	—
Alfalfa 1983	92.3	14.5	39.9	29.9	2.6	9.0	4800
Alfalfa 1984	93.0	24.1	38.4	28.4	2.5	8.4	6700