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EFFECTS OF SPOIL TEXTURE ON GROWTH OF K-31 TALL FESCUE

Abstract.—Growth of K-31 tall fescue (*Festuca arundinacea*) was significantly affected by the particle-size distribution, or texture, of four spoils from eastern Kentucky. Growth on spoils having no toxic chemical properties generally was greatest where texture consisted of about equal quantities of soil-size material and a coarser fraction (2 mm. to 6.4 mm.), probably because moisture and aeration were favorable. However, on two spoils, adverse chemical properties modified the effect of physical properties associated with texture. Toxic levels of Mn found in the smaller-size fractions probably reduced yields on one spoil. On another, the effect of texture was masked by toxic levels of Al in each of the three particle-size fractions.

Success or failure of attempts to revegetate spoil banks formed in the process of strip mining for coal depends on both chemical and physical properties of the spoil material. Effects of spoil chemical factors, such as pH and nutrient deficiencies, on plant establishment and growth have received some study. Effects of spoil physical properties, such as texture, on plant growth have received little investigation, yet the coarseness of the spoil surface is one of its most striking features. This note deals with the effects of spoil texture on the growth of K-31 tall fescue (*Festuca arundinacea*), a species commonly used in spoil reclamation.

Texture of *soils* commonly refers to the relative proportions of sand, silt, and clay in a soil mass, thus indicating its relative coarseness. Since spoil banks in the Appalachian region initially contain only a small amount of soil-size material, a textural classification of spoils based on relative amounts of sand, silt, and clay is meaningless. Spoil banks consist of a mixture of rock fragments and soil-size material; and, in contrast to soils, the particle-size distribution changes rapidly as spoil weathers. Therefore, spoil texture refers to a distribution of particles ranging from large rocks to soil-size material.

Spoil texture depends on the nature of the overburden from which the spoil was derived and on its degree of weathering. Spoil derived primarily from sandstone strata usually is initially coarser than spoil derived mainly from shale. Furthermore, shale fragments break down more rapidly into smaller particles during chemical and physical weathering than do sandstone fragments.

Methods

The effect of texture on plant growth may be influenced by chemical properties of the spoil, especially if the spoil is very acid. For this reason, four spoils from eastern Kentucky that varied widely in parent material and pH (index of acidity) were used in this study (table 1). Variation within individual spoils was minimized by collecting material of similar color, parent rock, and age (time since mining).

Each spoil was arbitrarily separated into three particle-size fractions:

A $<$ 2 mm. (soil size)
B 2 mm. to 6.4 mm.
C 6.4 mm. to 12.7 mm.

A series of 13 pots containing 2,000 g. of various proportions of each particle-size fraction was prepared for each spoil (table 2).

Table 1.—Some characteristics of the four spoils used in evalauating effects of texture on growth of K-31 tall fescue

Spoil number	Derived from predominantly—	pH	Age (since mining, years)
1	Acid sandstone	4.7	2
2	Sandstone	6.2	2
3	Calcareous shale	7.2	1/4
4	Shale	3.5	7

Table 2.—Percentage by weight of three particle-size fractions in each of 13 pots

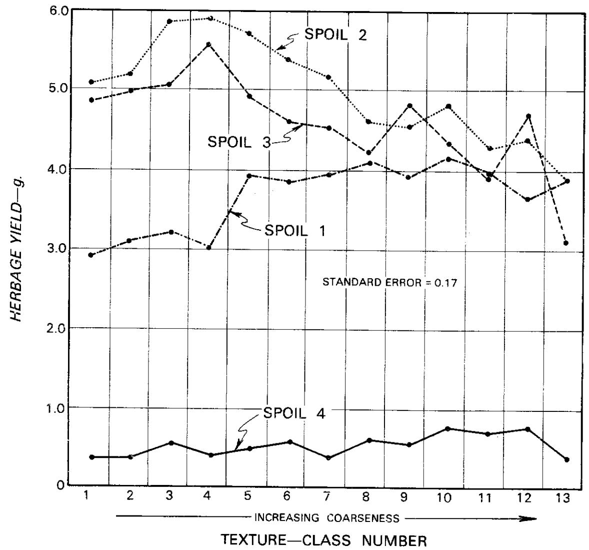
Texture-class number	Particle-size fraction		
	A	B	C
	< 2 mm.	2 to 6.4 mm.	6.4 to 12.7 mm.
	Percent	*Percent*	*Percent*
1	100	0	0
2	80	20	0
3	60	40	0
4	50	50	0
5	40	60	0
6	40	40	20
7	30	30	40
8	25	25	50
9	20	80	0
10	20	20	60
11	10	10	80
12	0	100	0
13	0	0	100

This series represented extremes of textures found in spoils, ranging from all soil-size material to completely coarse fragments. The series of pots was replicated three times. Since growth of grasses on most spoils is often nil unless phosphorus (P) and nitrogen (N) are supplemented, all pots were fertilized with 50 p.p.m. P from monocalcium phosphate and 50 p.p.m. N from ammonium nitrate. Fertilizer was thoroughly mixed into the spoil material, after which about 50 fescue seeds were planted in each pot. Distilled water was applied as required, and the grass grew in pots in the greenhouse for 3 months.

Results and Discussion

Herbage yield of tall fescue was markedly influenced both by texture and by spoil type (fig. 1). Furthermore, the texture x spoil interaction was highly significant, indicating that similar textures produced different growth responses on different spoils.

Top growth was generally greatest in spoils 2 and 3, both of which had relatively high pH values (table 1). In these two spoils,



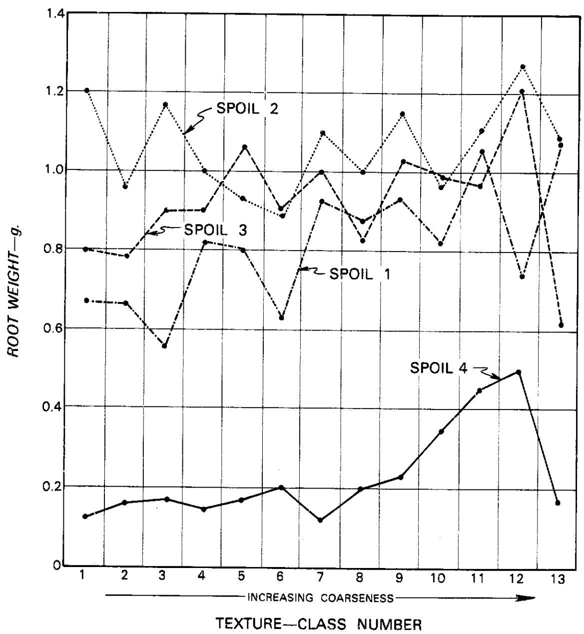


Figure 1.—Oven-dry top (herbage) and root weights of K-31 tall fescue as affected by particle size (texture) and four spoil types.

neither Al or Mn approached suspected toxicity levels (table 3). Pots containing equal portions of the soil-size fraction and fraction B gave greatest yields. As texture became coarser (increasing percentages of larger-size fractions), yields generally declined on these spoils (fig. 1). Several factors are likely involved in the de-

Table 3.—Some chemical properties of three particle-size fractions of four spoils

Spoil number	Size fraction	Mn[1]	Total acidity N KCl	Extractable Al	Extractable H
		p.p.m.	*me./100 g.*	*me./100 g.*	*me./100 g.*
1.	A	58	0.95	0.85	0.10
	B	58	.95	.70	.25
	C	20	.35	.20	.15
2.	A	12	.10	.00	.10
	B	9	.15	.00	.15
	C	5	.10	.00	.10
3.	A	28	.10	.00	.10
	B	13	.05	.00	.05
	C	9	.10	.00	.10
4.	A	17	8.00	6.50	1.50
	B	14	7.65	6.25	1.40
	C	13	6.55	5.18	1.37

[1] Extracted with *N* NH_4 OAc (pH 4.8).

creased yields. First, available moisture possibly reached critical levels in the coarsest spoils at times, especially in the top few inches since percolation through the coarse spoil was rapid. Secondly, the larger-size fraction possibly was unable to supply ample nutrients to meet plant requirements. Unpublished data indicate that size-fraction C yields considerably smaller quantities of plant nutrients than does the soil-size fraction.

Herbage yield in spoil 1 generally increased as texture became coarser (fig. 1). The reason for this different response, as compared to that of spoils 2 and 3, is probably adverse chemical properties of spoil 1 associated with the smaller particle sizes (table 3). Spoil 1 yielded 58 p.p.m. Mn from both fractions A and B, but only 20 p.p.m. in the coarser fraction C. Mn toxicity symptoms on legumes have been reported on acid spoils in eastern Kentucky (*1*).

Another possible reason for greater yields on coarser textures of spoil 1 is that Al may have been present in toxic amounts especially in the finer textures. Extractable Al ranged from a low of 0.20 me./100 g. (fraction C) to a high of 0.85 me./100 g. (fraction A). These figures are within the range of critical values of exchangeable Al for various species, soils, and methods of extraction, as summarized by Reeve and Sumner (*2*).

Herbage yield for all textures of spoil 4 was very low, ranging from 0.30 to 0.71 g. These poor yields are attributed to extremely high levels of exchangeable Al (6.50, 6.25, and 5.18 me./100 g. for fractions A, B, and C, respectively). Since all three size fractions contained toxic quantities of Al, the effect of texture on plant growth was masked by the adverse nutritional regime.

Root growth was generally greatest for fescue growing on spoils 2 and 3, and least for fescue growing on spoil 4 (fig. 1). No clear trend was apparent between spoil texture and root growth, except in spoil 1 and 4 where growth generally increased as texture became coarser. This is probably because high levels of Mn and Al were reduced to more tolerable levels. Poor root growth observed on spoil 4 is attributed to toxic levels of exchangeable Al in all size fractions.

Conclusions

Results of this study indicate that, in spoils having no adverse chemical properties (such as spoils 2 and 3), fescue growth is greatest where texture consists of about equal portions of soil-size material and particles 2 to 6.4 mm. Such a particle-size distribution probably provided optimum physical properties, such as aeration and moisture retention, for plant growth under the conditions of this study. However, in spoils with chemical properties that limit plant growth, such as in spoil 1 with its high Mn levels, coarser textures yield better growth, since less Mn is available from the larger particle-size fractions. Toxic amounts of exchangeable Al severely limited fescue growth on all textures of spoil 4. High rates of lime would have to be applied to this spoil to reduce exchangeable Al to plant-tolerable limits before adequate plant growth could be expected.

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