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CULTIVAR SELECTION, SEED STRATIFICATION AND SURFACE COVER EFFECTS ON SWITCHGRASS ESTABLISHMENT ON COAL MINE SPOIL

D.C. Ditsch, M. Collins, T.P. Demond and T.D. Phillips

INTRODUCTION

Surface mining in the Appalachian region of Kentucky often involves steep slopes and spoil limitations for revegetation not encountered in other reclamation situations. Herbaceous species (monocultures or mixtures) provide quick cover required in revegetation of mined land for control of erosion as well as promoting soil development, improving wildlife habitat, and livestock production through hay and pasture production as well as a potential use as renewable energy for cofiring with high sulfur coal. However, due to the many challenging chemical and physical characteristics of mine spoil, selection of adaptable herbaceous species should be carefully considered.

According to the Kentucky Department for Surface Mine Reclamation and Enforcement (DSMRE), more than 2 million acres have been surface mined in Kentucky. As a result of mining, approximately 200,000 acres of forested land has been converted to pasture/hayland since 1978. This land use conversion is responsible for a growing beef cattle industry that could begin to provide economical returns to the land sooner than

reforestation. Native warm-season grasses, such as switchgrass (*Panicum virgatum* L.), are suitable for wildlife habitat as well as livestock forage and biomass production for energy. Switchgrass is probably the most widely adapted of the warm season perennial grasses that are native to North America (Parrish and Wolf, 1993). This species, along with others such as big bluestem (*Andropogon gerardii* Vitman), were the dominant grass components of the tall grass prairies of the midwestern U.S., including some areas in Kentucky. Unlike some other C₄ grasses introduced from tropical regions, switchgrass has sufficient cold hardiness to survive throughout the U.S. Adaptation to warm temperatures, low plant moisture availability, low soil pH and fertility are advantages of switchgrass for survival on mine spoil (Jung et al., 1988).

Unfortunately, seedling vigor of switchgrass is limited and seed dormancy is frequently high, resulting in establishment failures. Seedling growth rate is often slow compared with many cool season species, making it a less desirable species where rapid ground cover for erosion control and slope

stabilization are needed. Establishment periods of 2 years or more are common (Wolf et al., 1988). The objective of this study was to determine cultivar, seed treatment and surface cover effects on switchgrass establishment on reclaimed mine spoil.

METHODS

A factorial experiment with two switchgrass cultivars, two seed stratification treatments and three establishment treatments was conducted in Breathitt Co. in the eastern coal fields of Kentucky. Cultivars were 'Alamo' and 'Cave-in-rock' (CIR). Seed of each cultivar was divided into two equal portions and either stratified or left untreated. Stratified seed were soaked in water overnight, drained and refrigerated at 39° F for 1 month then dried with unheated ambient air prior to seeding. Surface cover treatments were (1) seeded with no mulch or companion crop, (2) seeded with oat (*Avena sativa* L.) at a rate of 84 lbs/acre, or (3) mulched with wheat straw at a rate of 4000 lbs per acre after seeding.

Coal surface mine spoil was primarily a mixture of blasted sandstone and gray shale. A seedbed was prepared using a rotary tine tiller. Switchgrass was seeded at the rate of 10 lbs per acre using a small plot drill on 15 June, 1994. Plots measured 3 x 6.5 ft. Plots were arranged in a split plot design with surface cover treatment as the main plot and cultivar x stratification combinations as the sub-plots. Each treatment was replicated four times. Nitrogen (N), in the form of NH_4NO_3 , was applied at the rate of 75 lbs per acre at the time of seeding and 50 lbs per acre at the time of growth initiation in the second year. Initial soil test results were as follows: water pH 7.89, buffer pH 7.42, phosphorus (P) 7 lbs/acre, potassium (K) 500+ lbs/acre and potential acidity 0. Phosphorus and K were applied according to soil test recommendations for grass pasture production in Kentucky.

Seedling stand density was measured on 14 July, 1 August, and 14 September following seeding by counting the number of emerged seedlings in a 1 meter (39 inch) section of row in each plot. At the last sampling, tiller number per plant and seedling weight were determined by cutting the shoots from 10 randomly selected seedlings at the soil surface. Samples were dried at 140° F for 48 hrs for dry matter determination. Percentage ground cover by switchgrass was estimated visually on 7 June, 1995 and shoot biomass measured by harvesting in Aug., 1995 and July, 1996.. The data were analyzed by analysis of variance procedures of SAS (1985) and means separated using the LSD test.

RESULTS AND DISCUSSION

Germination of untreated seed averaged 38.3 and 9.5% for Alamo and CIR, respectively. Germination increased to 47% and 83% for the same cultivars, respectively, after the 4-wk stratification treatment. However, some reversion to dormancy occurred with air drying to prepare the seed for planting.

Stand Density

Dry soil conditions following seeding resulted in slow emergence and reduced early seedling growth rates across all treatments. Slow emergence of warm-season grasses compared to cool-season grasses is commonly observed on both mine spoil and undisturbed soils due in part to the morphological differences in root development between cool and warm-season grasses (Figure 1). Adventitious roots are important to seedling establishment because they can conduct much more water than the smaller diameter seminal roots. For most cool-season C_3 grasses, adventitious roots generally arise from the coleoptilar node just above the seed. However, warm-season grasses elongate their mesocotyl (subcoleoptile internodes) placing

adventitious roots near the soil surface making a constant water supply critical. Rapid soil drying and periods of drought common to mine spoil after initial spring rains are probably responsible for a lack of consistent establishment of switchgrass and other warm-season grasses in mine spoil revegetation.

Treatment effects were inconsistent or absent for seedling stand density measured in July (2.0 plants per 3 ft of row) and August (3.9 plants per 3 ft or row) of the seeding year. In September, stand density ranged from 2.3 plants per 3 ft of row for Alamo control plots to 6.3 for CIR with oat (Table 1). Stand densities of Alamo benefited more from mulching than did CIR. In control and oat treatments, CIR had greater stand densities than Alamo but the two cultivars were similar when straw mulch was added. Stratification did not influence stand density except at the July count when treatment increased CIR stands from 1.5 to 2.4 seedlings per 3 ft or row but decreased Alamo stand density from 3 to 1.5 seedlings per 3 ft or row. Ground cover evaluated about 1 year after seeding was low overall but was improved by mulch compared with other treatments (Table 1).

Tiller Number and Size

Across treatments, CIR had more tillers per plant in September of the seeding year than Alamo (Table 1). Straw mulch increased Alamo tiller numbers substantially compared with other treatments but did not do so for CIR. Plants in straw mulched plots had 2.7 tillers per plant compared with 1.8 for the control when seed were stratified. However, when seed were not stratified, tiller number per plant did not differ among establishment treatments (data not shown).

Dry weight per tiller in September of the seeding year was doubled by straw mulch compared with control or oat treatments (Table 1). For Alamo, where tiller numbers were also increased by mulching, total mass

per plant was increased more than 4 fold by the mulch treatment.

Ground Cover and Dry Matter Yield

Ground cover was assessed during spring of the year following seeding. Weed species were present but not at densities great enough to influence switchgrass growth significantly. Straw mulch increased ground cover for both cultivars compared with control and oat treatment (Table 1). Dry matter yield was low, 177-258 lbs per acre, when measured during mid-summer of the year following seeding and was not affected by any treatment. Dry matter yield increased substantially in 1996 but was not affected by any treatment (Table 1).

SUMMARY

Seed stratification increased percent germination but effects were minimal for all variables measured to assess establishment success. Environmental conditions common to mine spoil, such as moisture stress and surface crusting may have been greater factors limiting emergence than seed dormancy. Observations indicate that moisture was conserved by the mulch and that crusting was substantially alleviated in that treatment. Deeper planting may also extend the duration of adequate moisture supplies and improve survival for seed germination and growth in regions where precipitation is adequate, yet surface drying is rapid. These data clearly show that the straw mulch treatment was superior to the control and oat companion crop treatments in terms of seeding year stand density, plant weight, tiller weight, and second year ground cover but did not increase dry matter yield measured in years 2 and 3. Switchgrass dry matter yield and percent ground cover increased substantially in year 3 across all treatments. However, overall yield level and early ground cover protection was extremely low during this study period raising a concern

about the use of switchgrass in areas with a high soil erosion potential. More research is needed to identify other cultivar and management techniques that may accelerate the rate of switchgrass establishment.

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Table 1. Seedling stand density and tiller number per plant in autumn of the seeding year for two switchgrass cultivars as affected by surface cover treatments[†].

Cultivar	Surface Cover Treatment	Autumn 1994 (seeding year)				Summer 1995		Summer 1996	
		Stand Density	Tiller Number	Plant Weight	Tiller Weight	Ground Cover	Yield	Ground Cover	Yield
		No./3 ft	No./ plant	g	g per tiller	%	lbs/ac	%	ton/ac
Alamo	Control	2.3	1.5	0.20	0.15	16.3	258	44.7	1.4
	Oat companion crop	2.7	1.9	0.30	0.15	13.1	177	34.6	0.9
	Straw mulch	5.5	2.7	0.86	0.31	37.5	252	49.3	1.6
Cave-in-rock	Control	4.7	2.6	0.26	0.11	14.4	196	33.1	1.2
	Oat companion crop	6.3	2.5	0.25	0.10	13.1	197	41.1	0.9
	Straw mulch	6.1	2.3	0.47	0.22	28.1	180	36.5	1.2
	LSD, 0.05	1.1	0.2	0.10	0.05	5.8	ns	ns	ns

[†]All values averaged across stratification treatment due to lack of significance at the 95% level of probability.

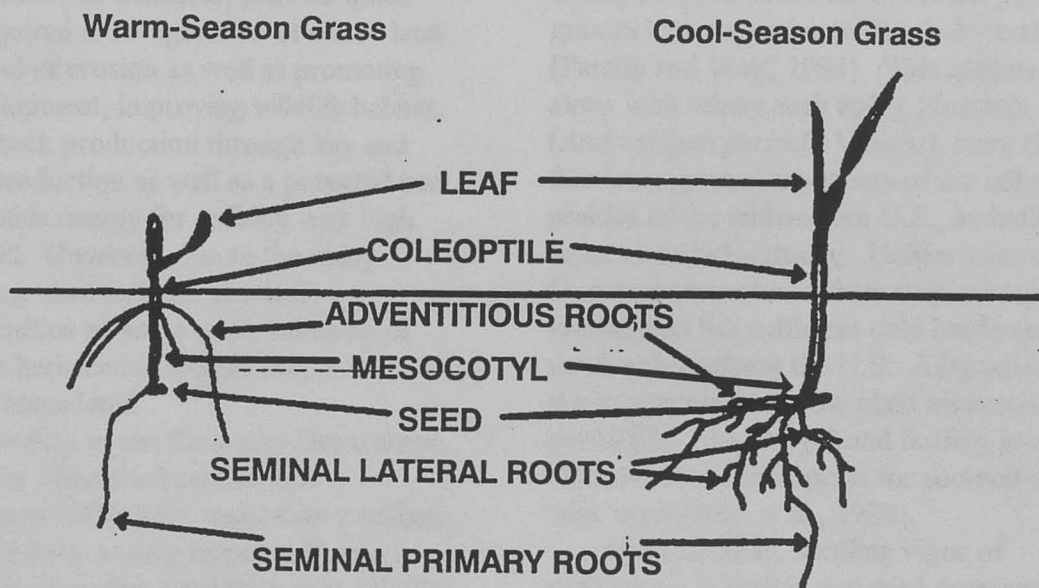


Figure 1. General rooting depths and morphological characteristics of cool and warm-season grasses. Adapted from Hyder (1974); Ries and Hoffmann (1991).

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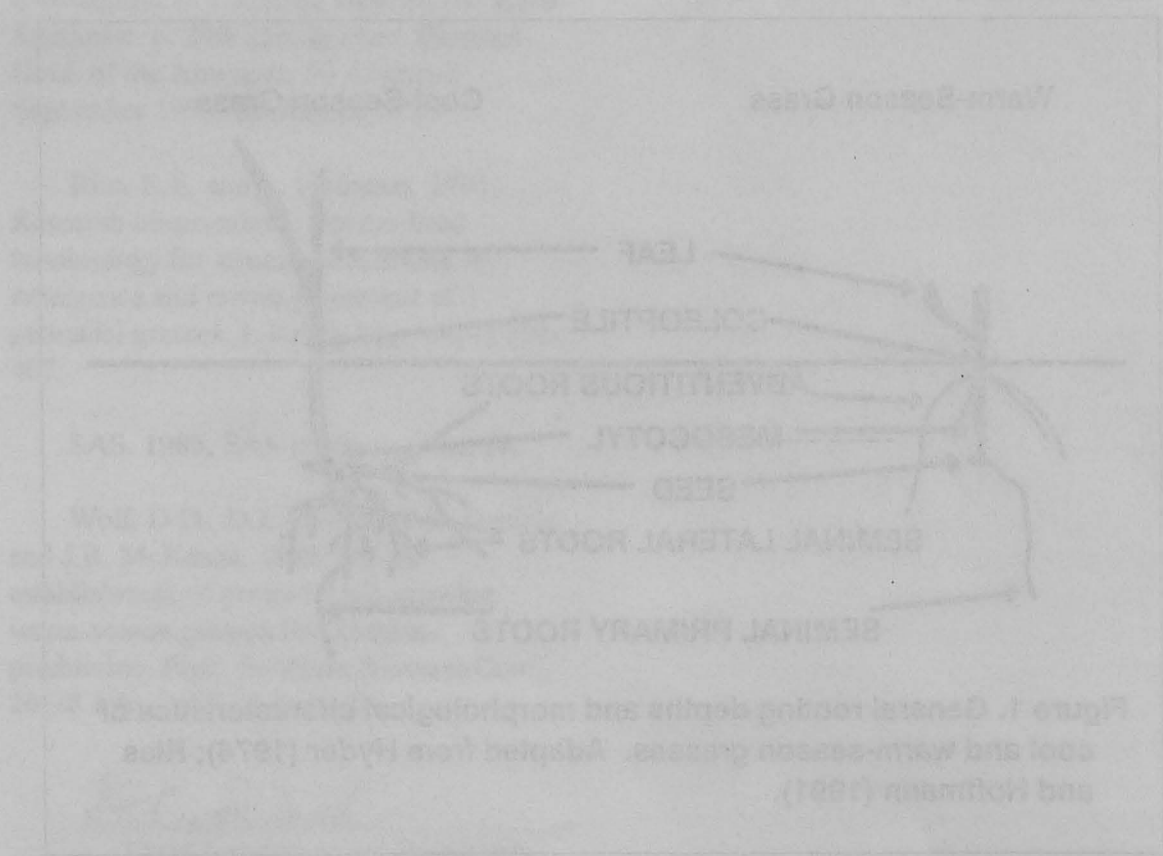


Figure 1. General rooting habits and morphological characteristics of cool and warm-season grasses. Adapted from Hyder (1975), Hux and Hofmann (1981).