CULTIVAR AND SEED STRATIFICATION EFFECTS ON SWITCHGRASS ESTABLISHMENT ON COAL MINE SPOIL

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ABSTRACT
Warm season perennial grasses such as switchgrass (*Panicum virgatum* L.) provide useful wildlife habitat on reclaimed surface mined land but stand establishment is often slow. Two switchgrass cultivars: (1) 'Alamo' and (2) 'Cave-in-rock', two seed stratification treatments: (1) wet chilled and (2) untreated, and three establishment treatments: (1) no mulch or companion crop, (2) seeded with oat (*Avena sativa* L.), or (3) mulched with wheat straw were compared in a factorial experiment. In Sept. after spring seeding, stand density ranged from 2.5 seedlings m^{-1} of drill row for Alamo control plots to 6.8 for CIR with oat. Stand densities of Alamo benefitted more from mulching than did CIR. Straw mulch increased Alamo tiller numbers per plant but did not do so for CIR. Stratification effects were small. These results show that mulching greatly improved seedling survival and growth in this environment.

KEYWORDS
Reclamation, revegetation, wildlife, warm-season grass

INTRODUCTION
According to the Kentucky Department for Surface Mine Reclamation and Enforcement (DSMRE), more than 0.83 million ha have been surface mined in Kentucky. Surface mining in the Appalachian region of Kentucky often involves steeper slopes, making stabilization difficult. Herbaceous species, especially perennials, provide quick cover for control of erosion and other benefits such as soil development, wildlife habitat, and livestock production (Schroeder, 1985). Switchgrass is a warm season perennial grass native to North America (Parrish and Wolf, 1993). This species, along with others such as big bluestem (*Andropogon gerardii* Vitman var. *Gerardii* Vitman), were the dominant grass components of the tall grass prairies of the Midwestern U.S. Adaptation to warm temperatures and deep rooting are advantages of warm season grasses during periods of low moisture availability (Jung, 1986). Switchgrass had more than five times the root mass of orchardgrass (*Dactylis glomerata* L.) in the surface 15 cm but also had substantial rooting below 30 cm. These species are adapted to conditions of low soil pH and fertility (Jung et al., 1988).

Seedling growth rates of warm season grasses are often slow compared with many cool season crop species and compared with competing weeds (Masters, 1995). Establishment periods of 2 yr. 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'. 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 4°C for 1 month. prior to planting. Stratified switchgrass was dried with unheated ambient air prior to seeding. Establishment treatments were (1) seeded with no mulch or companion crop, (2) seeded with oat (*Avena sativa* L.) at a rate of 94 kg ha^{-1}, or (3) mulched with wheat straw at a rate of 4.5 Mg ha^{-1} after seeding.

Coal surface mine spoil was prepared using a rotary tine tiller. Switchgrass was seeded at the rate of 11 kg ha^{-1} using a small plot drill on 15 June, 1994. Plots measured 0.9 x 6 m. Plots were arranged in a split plot design with establishment treatment as the main plot and cultivar x stratification combinations as the sub plots. Each treatment was replicated four times. Nitrogen, in the form of NH_4NO_3, was applied at the rate of 84 kg ha^{-1} at the time of seeding and 56 kg ha^{-1} at the time of growth initiation in the second year. 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 Aug., and 14 Sept. following seeding by counting the number of emerged seedlings in a 1 m 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 60°C for 48 h for dry matter determination. Percentage ground cover by switchgrass was estimated visually on 7 June, 1995 and shoot biomass measured by harvesting on 15 Aug., 1995. The data were analyzed by analysis of variance procedures of SAS (1985) and means separated using the LSD test.

RESULTS AND DISCUSSION
Germination averaged 38.3 and 9.5% for unstratified Alamo and CIR, respectively. Values increased to 47 and 83% for the same cultivars, respectively after the 4-wk stratification treatment. Some reversion to dormancy occurred with air drying to prepare the seed for planting.

Stand Density. Dry conditions following seeding resulted in slow emergence and reduced early seedling growth rates across all treatments. Treatment effects were inconsistent or absent for seedling stand density measured in July (2.2 m^{-1}) and Aug. (4.2 m^{-1}) of the seeding year. In Sept. stand density ranged from 2.5 seedlings m^{-1} for Alamo control plots to 6.8 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 1.6 to 2.6 seedlings m^{-1} but decreased Alamo stand density from 3.2 to 1.6 seedlings m^{-1}. 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 Sept. of the seeding year than did Alamo (Table 1). Straw mulch increased Alamo tiller numbers substantially compared with other treatments but did not do so for CIR. Plants in mulched plots had 2.7 tillers $plant^{-1}$ compared with 1.8 for the control when seed were stratified. However when seed were not stratified, tiller number per plant did not differ, 2.3 to 2.5 $plant^{-1}$, among establishment treatments ($P < 0.05$). Weight per tiller in Sept. 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 tiller mass per plant was increased more than 4 fold by the mulch treatment.

Ground Cover and Shoot Mass. 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. Mulch increased ground cover for both cultivars compared with control and oat treatments (Table 1). Dry matter yield was low, 0.2-0.3 Mg ha^{-1}, when measured during mid-summer of the year following seeding and was not affected by any treatment (Table 1).

Seed stratification effects were minimal for all variables reflecting establishment success, even though seed germination was affected. Environmental conditions may have been such that seed dormancy was not the main limitation to emergence. Our finding that stratification effects were minimal 1 and 2 months. after seeding as well as later supports this possibility. Moisture stress and crusting are common limitations in the mine spoil environment. These data show clearly that the mulch treatment was superior to the control and oat companion crop treatments. Observations indicate that moisture was conserved by the mulch and that crusting was substantially alleviated in that treatment.

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Table 1
Seedling stand density and tiller number per plant in autumn of the seeding year for two switchgrass cultivars with different seed stratification and establishment treatments.

		Autumn, seeding year				Spring, second year	
Cultivar	Establishment treatment	Stand density	Tiller number	Plant weight	Tiller weight	Ground cover	Yield
		—$\#m^{-1}$—	—# $plant^{-1}$—	—g—	—g $tiller^{-1}$—	—%—	—$Mgha^{-1}$—
Alamo	Control	2.5	1.5	0.20	0.15	16.3	0.289
	Oat companion crop	2.9	1.9	0.30	0.15	13.1	0.198
	Straw mulch	6.0	2.7	0.86	0.31	37.5	0.282
Cave-in-rock	Control	5.1	2.6	0.26	0.11	14.4	0.220
	Oat companion crop	6.8	2.5	0.25	0.10	13.1	0.221
	Straw mulch	6.6	2.3	0.47	0.22	28.1	0.202
LSD, 0.05		1.2	0.2	0.10	0.05	5.8	ns