

TECHNICAL

U. S. DEPARTMENT OF AGRICULTURE

NOTES

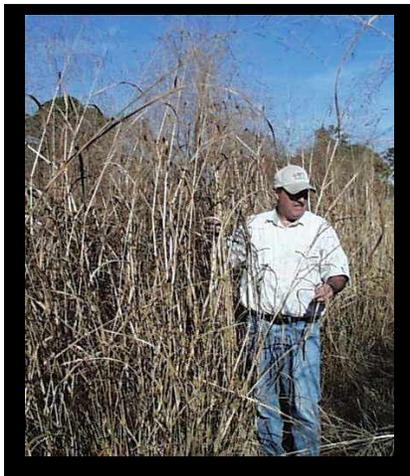
IOWA STATE OFFICE

NATURAL RESOURCES CONSERVATION SERVICE DES MOINES, IOWA

Agronomy #35

Date: January 2009

Subject: SWITCHGRASS FOR BIOMASS PRODUCTION BY VARIETY SELECTION
AND ESTABLISHMENT METHODS FOR MISSOURI, ILLINOIS, AND IOWA



***Jerry Kaiser, Plant Materials Specialist
Steve Bruckerhoff, PMC Manager***

Switchgrass (*Panicum virgatum* L.) is a native, deep-rooted, warm-season grass with short, stout rhizomes and heavy biomass growth during late spring and early summer. The species occurs naturally in every State in the continental United States except for Oregon, Washington, and California (USDA, NRCS 2006b). It is an abundant seed producer. Clean seed yields of 225 pounds per acre have been documented at the USDA, NRCS Plant Materials Center (PMC) at Elsberry, Missouri.

Switchgrass tolerates a wide range of soil conditions and is widely acclaimed as a conservation plant for erosion control, pasture and hayland planting, wildlife habitat, and native prairie restoration. Interest in switchgrass as a renewable biofuel resource has grown in recent years.

Dry matter biomass yields and other information were compiled at three sites in Missouri from 1993-1995, Illinois from 1992-1994 and Iowa from 1994-1996. The effects of seed origin (parentage) on plant performance were apparent. Twelve seed sources/varieties of switchgrass were evaluated. Southern seed sources generally had heavier biomass production. Northern

seed sources moved more than 200 miles southward from their origin generally performed poorly. Biomass was significantly less than local or more southern origin sources.

Trial Sites

The trial sites were studies in cooperation with several partners: The USDA Natural Resources Conservation Service, Plant Materials Center, Elsberry, Missouri; in cooperation with the University of Missouri, Southwest Research Center, Mt. Vernon, Missouri; the University of Illinois, Orr Agricultural Research Center, at Perry, Illinois; and the University of Northern Iowa, Tallgrass Prairie Center, Cedar Falls, Iowa.

Growing seasons at the three locations varied from an average 177 days at Cedar Falls, Iowa, to an average of 232 days at Mt. Vernon, Missouri. Average annual precipitation ranged from 43.7 inches at the Mt. Vernon site to 33.7 inches at the Cedar Falls site. Seven different species of warm-season grasses were evaluated at each site. Each species included two or more varieties or seed sources. Switchgrass is the only species presented in this report.

University of Missouri, Southwest Research Center, Mt. Vernon Missouri

Major Land Resource Area-116B-Springfield Plains, Ozark Border.

Soils Information-Hoberg-silt loam; the Hoberg series consists of very deep, moderately well drained soils that have a fragipan. They formed in a thin mantle of loess and the underlying residuum from cherty limestone. Slopes range from 2 to 8 percent. Permeability is moderate above the fragipan, slow in the fragipan and moderate below the fragipan

Average annual precipitation for the four years of the biomass study was varied at this location. In 1991 the establishment year rainfall was 20% (-8.95) below the normal average of 43.73 inches. The highest biomass production was in 1993 and 1994 following rainfall in 1992 that was 28% (12.26) above normal and 1993 that was 40% (17.28) above normal. Average biomass yields were generally excellent on the upland Hoberg silt loam soils. Alamo and Kanlow produced an average of 13,500 pounds per acre or greater. All varieties were in the 90% range in percent stand the second year after planting except for Grenville 78%, and Shelter at 45%. Alamo and Kanlow were the tallest varieties at the average forage height of 6 feet. Alamo and Kanlow were also the latest in the date of first seedhead emergence, Alamo August 7, and Kanlow July 28

University of Illinois, Orr Research Center, Perry, Illinois

Major Land Resource Area-115C-Central Mississippi Valley Wooded slopes.

The soil is a Muscatine silt loam; The Muscatine series consists of very deep, somewhat poorly drained soils formed in loess. These soils are on summits of interfluvies on dissected till plains and on treads and risers on stream terraces. Slopes range from 0 to 5 percent

Average annual precipitation for the four years of the biomass study was varied at this location. In 1990 the establishment year was 23% (8.83") above normal of a 17 year average of 39.18 inches. The highest Biomass was in 1993 when rainfall was 38% (14.70) above normal.

Average biomass yields were good. The highest production was Kanlow 9,729 pounds per acre, followed by Alamo 8,820 pounds per acre; however, Alamo did not achieve greater than 90% cover until the third year. The varieties Kanlow, Cave-in-Rock, Carthage and Pathfinder were in

the 90%-100% range in percent stand the year following planting. The remaining varieties did not achieve those levels until the third growing season. Kanlow was the tallest with an average forage height of 5.7 feet. Kanlow, July 25, and Alamo, July 17, were the latest in dates of first seedhead emergence, late boot stage.

University of Northern Iowa, Tallgrass Prairie Center, Cedar Falls Iowa

Major Land Resource Area-104-Eastern Iowa Till Prairie

The soils on this site are a well drained Kenyon clay loam and Olin fine sandy loam. The Kenyon series consists of very deep, moderately well drained soils formed in 30 to 75 centimeters of silty or loamy sediments and the underlying till. These soils are on interfluves and side slopes on dissected till plains on the Eastern Iowa and Minnesota Till Prairies. Slope ranges from 2 to 35 percent.

The Olin series consists of very deep, well drained soils formed in 60 to 91 centimeters (24 to 36 inches) of loamy sediments and in the underlying glacial till. These soils are on interfluves and side slopes on dissected till plains. Slopes range from 2 to 14 percent

Average annual precipitation for the four years of the biomass study was varied at this location. In 1992 the establishment year precipitation was below normal 8% (-2.73"). The highest biomass was in 1994 following above normal precipitation 57% (19.37") in 1993 and 5% (1.60") in 1994. In 1995 and 1996 a 12% below normal precipitation resulted in lower biomass yields.

The highest biomass yield for the three year average was Kanlow 12,143 pounds per acre, Blackwell 11,731, Shelter 11,147, and Carthage 10,272.

The varieties Kanlow, Cave-in-Rock, Shelter, Carthage, Alamo, and Forestburg were in the 90%-100% range in percent stand the second year following planting. The remaining varieties did not achieve those levels until the third growing season.

Kanlow, August 18th, and Alamo, August 14th, had the latest average date of first seedhead emergence (late boot stage).

Methods and Materials

Procedure:

The three sites were located within the PMC service area for the study. The northern site is at Cedar Falls, Iowa (Northeast Iowa), the central site is at Perry, Illinois (West Central Illinois) and the southern site is at Mt. Vernon, Missouri (Southwest Missouri). Varieties of the most commonly used switchgrass (See Table #1) were planted in a randomized complete block with three replications. Plot sizes at Perry Illinois were 15' X 50' in a prepared seedbed that was broadcast. Plot sizes for Mt. Vernon Missouri and Cedar Falls, Iowa were 12' X 50' and were in a prepared seedbed planted with a drill.



The second year after seeding, each site was subjected to a spring burn. Each plot was monitored for establishment the year of planting but was not evaluated until the second year. Evaluation criteria are annual biomass yield, plant height, forage quality, percent stand, and plant phenology, which compared plant maturity.

The data collected for annual biomass yield production was done only once per year, typically at the end of the growing season. This did not take into account regrowth potential but rather a full season total growth comparison. For nonplanted species, (primarily weeds), a sample was taken and used to adjust the dry matter yields to better represent the switchgrass being evaluated. Precipitation data for each site can be found in Table #2.

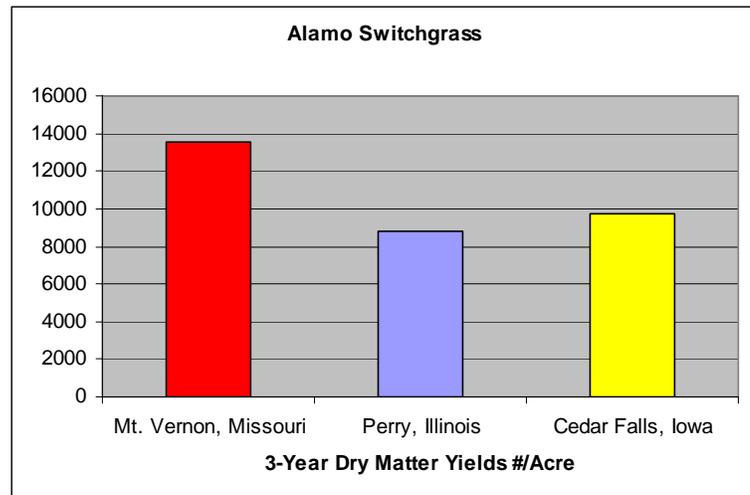
Biomass Production

A two foot by seven-foot sample was cut with a forage harvester to determine biomass yield. A representative stand was harvested from each plot. Plot borders were excluded and an estimate of percent dry matter weed content in the sample was deducted from the total sample weight.



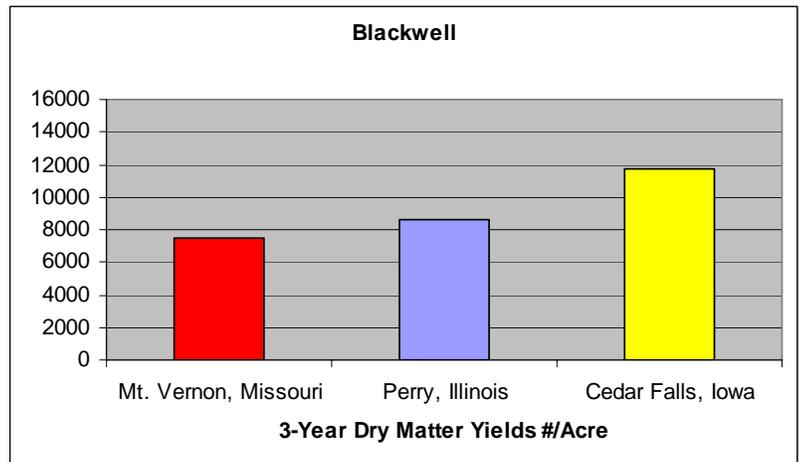
Variety/SeedCollectionSource Alamo

Original seed was collected near the town of George West, in south central Texas. Selection for longer wider leaves, taller and greater forage potential. Maturity is one to two months later than other southern selections like Blackwell. Alamo was a USDA Natural Resources Conservation Service release from Knox City Texas.



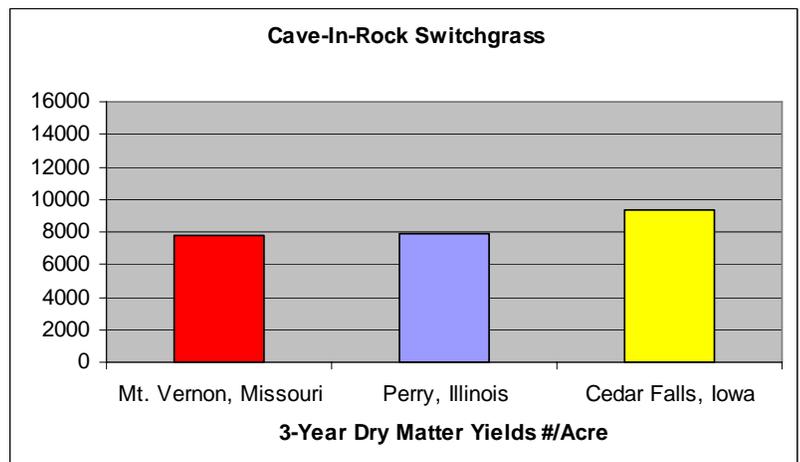
Blackwell

Harvested from a single plant in a native prairie near the town of Blackwell, in north central Oklahoma. This is an upland type switchgrass of medium height that is leafy and has large stems. Total forage yield, disease resistance, and seedling vigor is good. It has a wide area of adaptation. Blackwell was released by the USDA Natural Resources Conservation Service and the Kansas Agricultural Experiment Station.



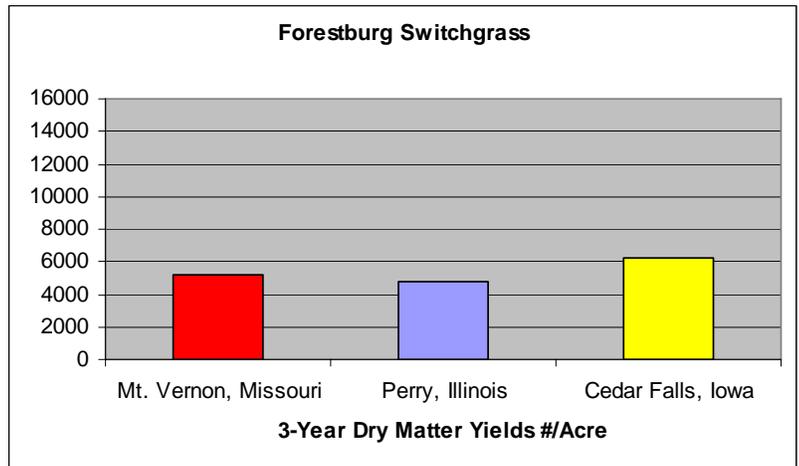
Cave-in-Rock

Selected from a native stand near the town of Cave-in-Rock in southern Illinois. It was selected for seedling vigor, disease resistance, higher seed yields, and resistance to lodging. This is a lowland type of switchgrass. It is tolerant to flooding, but will also withstand droughty soils. Cave-in-Rock was released by the USDA Natural Resources Conservation Service Elsberry, Missouri and the Agricultural Experiment Station.



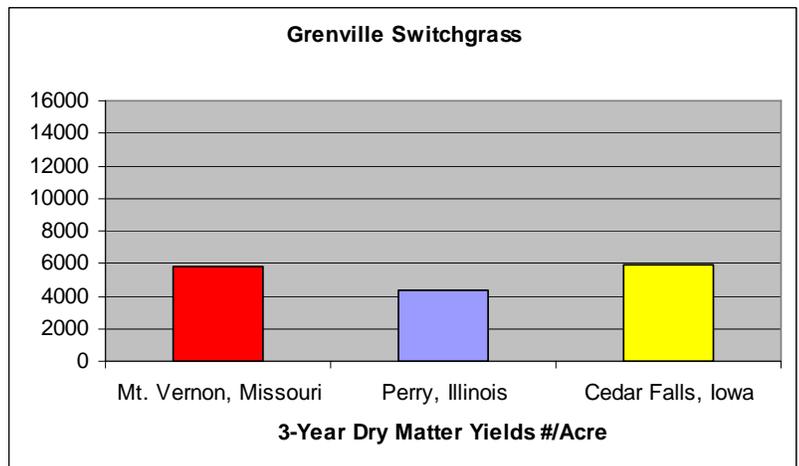
Forestburg

A composite (SD-149) of four accessions collected from native stands near the town of Forestburg, in east central South Dakota. Early maturity, persistence, forage yield and quality, winter hardiness, and seed production were key selection criteria. Forage production at northern latitudes exceeds production of Dacotah and is similar to Nebraska 28 and Sunburst. Forestburg was a joint USDA Natural Resources Conservation Service and Agricultural Research Service release.



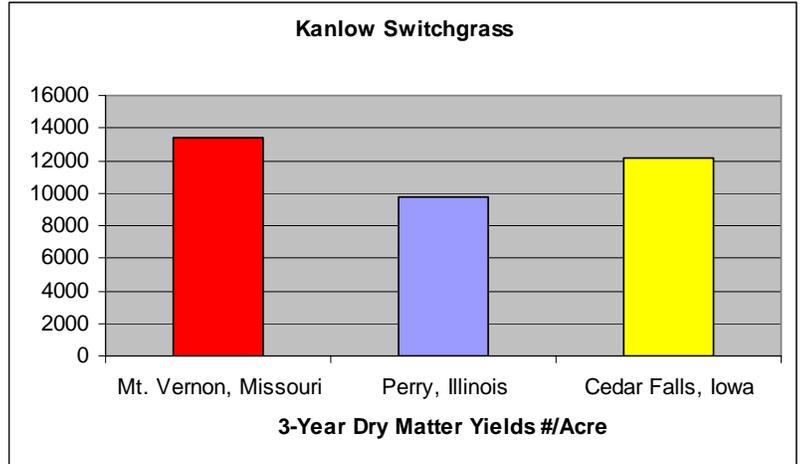
Grenville

A collection near the town of Grenville, in North east New Mexico at an elevation of 1800m (4938ft.) with annual precipitation of 400mm (15.7 inches). A intermediate type between northern and southern geographic strains. Leafy, fine stemmed and remain green well in the fall. Medium maturity date. Grenville is a release from USDA, Natural Resources Conservation Service, Los Lunas, New Mexico.



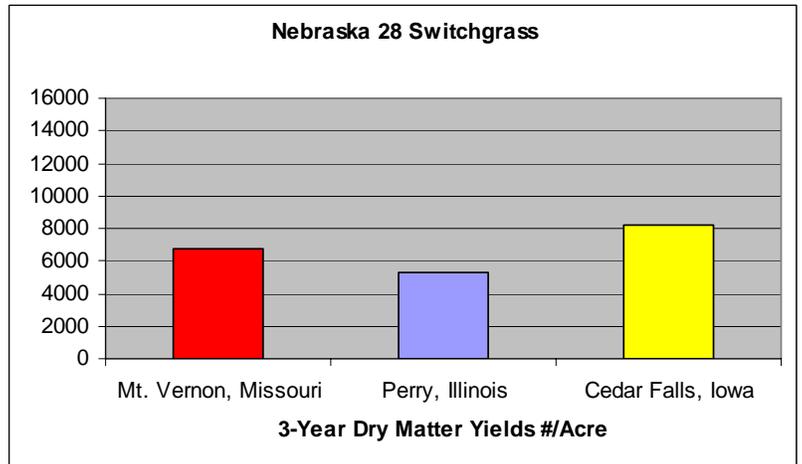
Kanlow

Original seed was collected near the town of Wetumka in East central Oklahoma, on a bottomland site. Selection for leafiness, vigor, and retention green leaf blades late in season. It is a tall coarse lowland type adapted to lowlands with high water tables but will perform well on an upland soils. Kanlow was released by the Kansas Agricultural Experiment Station, the USDA Natural Resources Conservation Service, and the Agricultural Research Service.



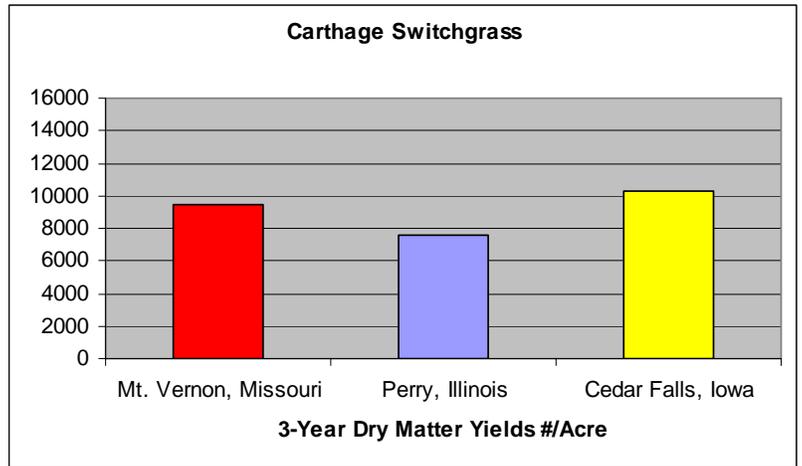
Nebraska 28

Collected from a native switchgrass stand in Holt County in northeast Nebraska. This is a relatively early maturing strain of switchgrass representative of the Nebraska sandhill types. There is considerable variation in plant type. The average plants are semi-decumbent, with fine stems of moderate height, bluish green, and leafy. It is susceptible to rust in areas with longer growing seasons. Nebraska 28 was released by the Nebraska Agricultural Experiment Station, the USDA Natural Resources Conservation Service, and the Agricultural Research Service.



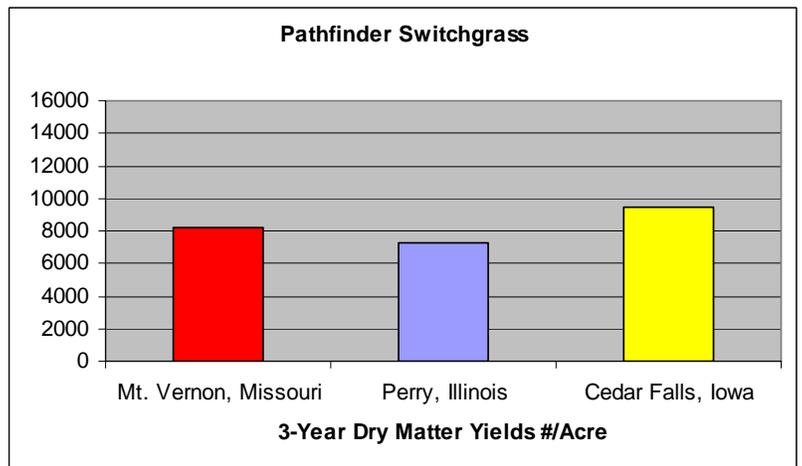
Carthage

A single clone collected vegetatively near the town of Carthage, in central North Carolina. It is leafy and has better than average spread, high nutrient value, and early spring recovery. Seed production is fair. Carthage was released from The USDA Natural Resources Conservation Service, Cape May New Jersey.



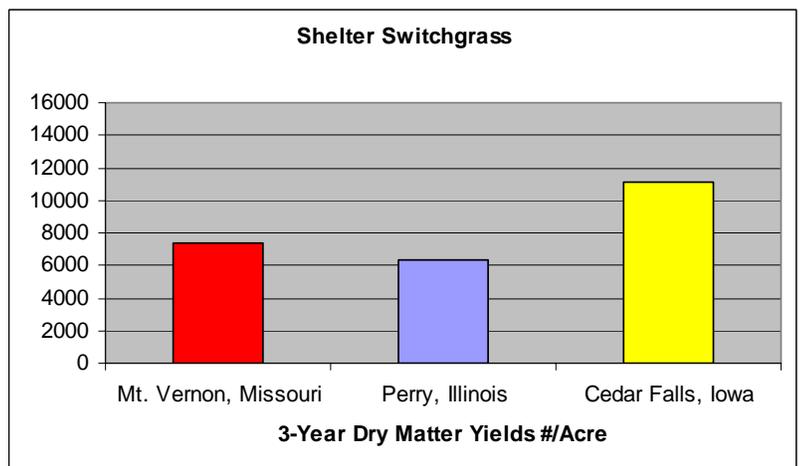
Pathfinder

Originated from numerous domestic collections from Nebraska and Kansas. It is winter hardy, vigorous, leafy, late maturing, and rust resistant in region of adaptation. Stand establishment and forage production is good. Pathfinder was released by the Nebraska Agricultural Experiment Station, the USDA Natural Resources Conservation Service, and the Agricultural Research Service.



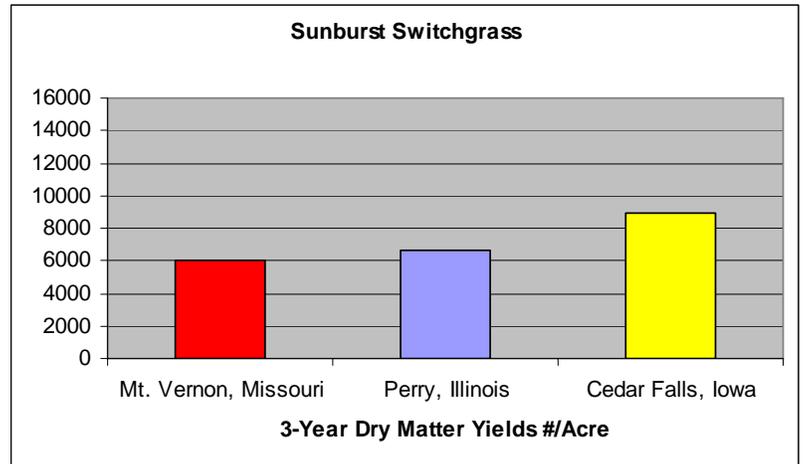
Shelter

Originated from a collection located near the town of St. Mary's, in North West, West Virginia. The original selection was selected for upright form and stiff stems. Additional selections improved the number of stems, early maturity, and large stem diameter. Shelter has thick stems and fewer leaves than other released varieties, except for Kanlow. Shelter reaches full anthesis 7-10 days earlier than Blackwell. Shelter was released by the USDA, Natural Resources Conservation Service, Big Flats, New York.



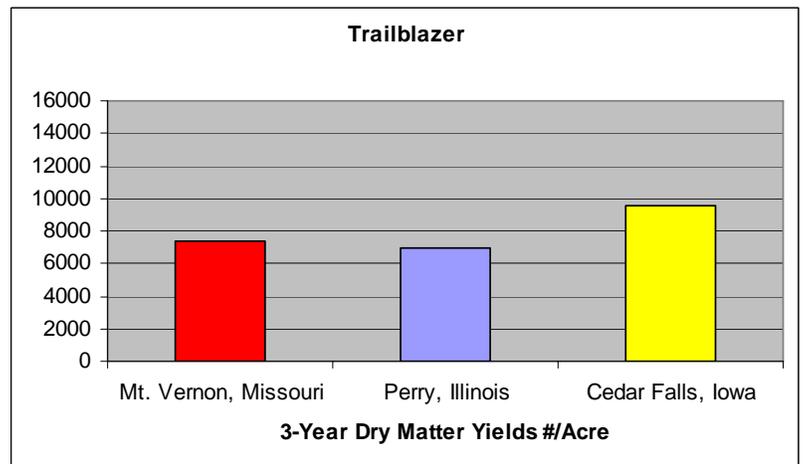
Sunburst

Original seed was collected near the town of Yankton in southeastern South Dakota. Selections from original seeded plants were chosen for large seed size, higher seedling survival and better stand establishment. It is a medium maturity selection with good forage yields. Sunburst has a broad area of adaptation and has performed well in trials along the Canadian border in North Dakota.



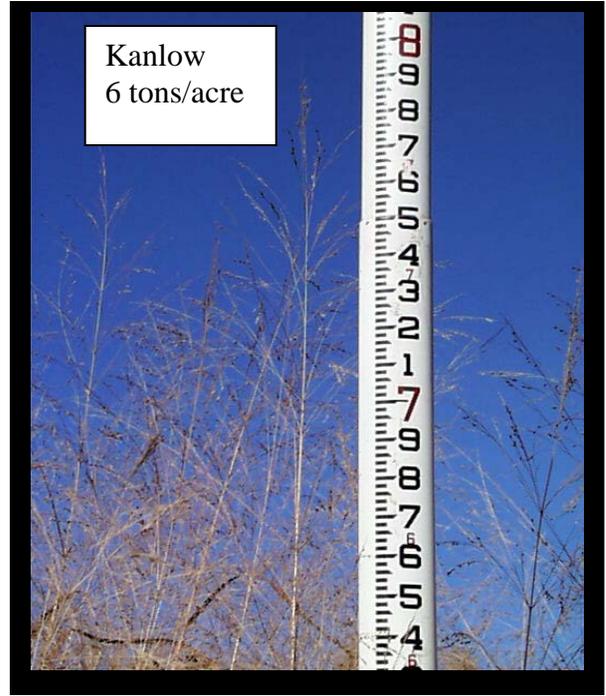
Trailblazer

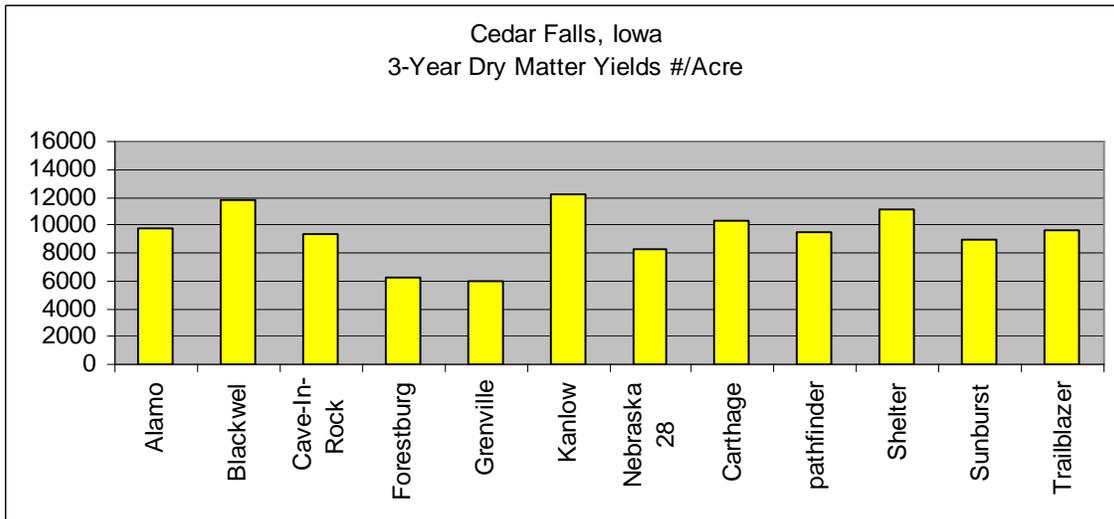
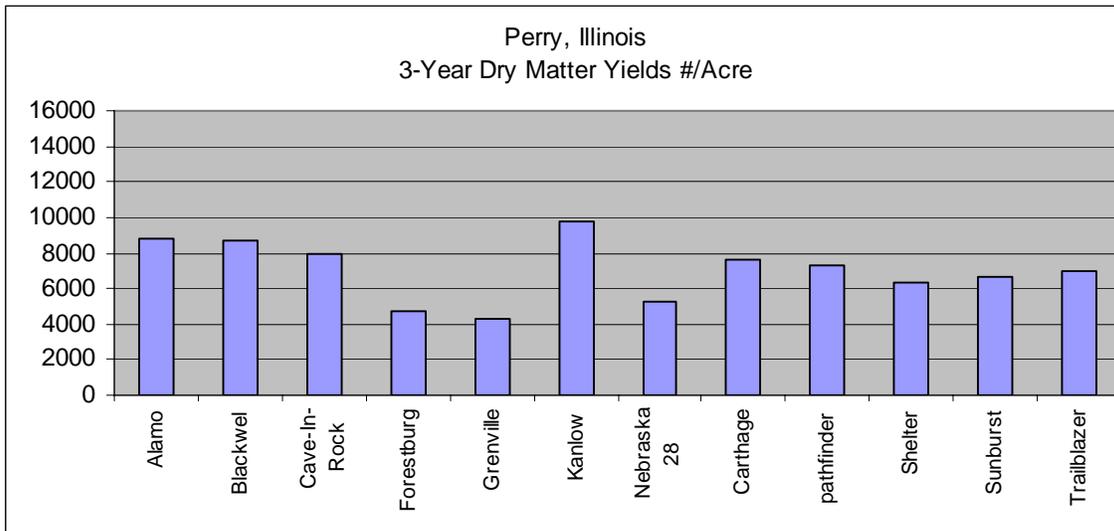
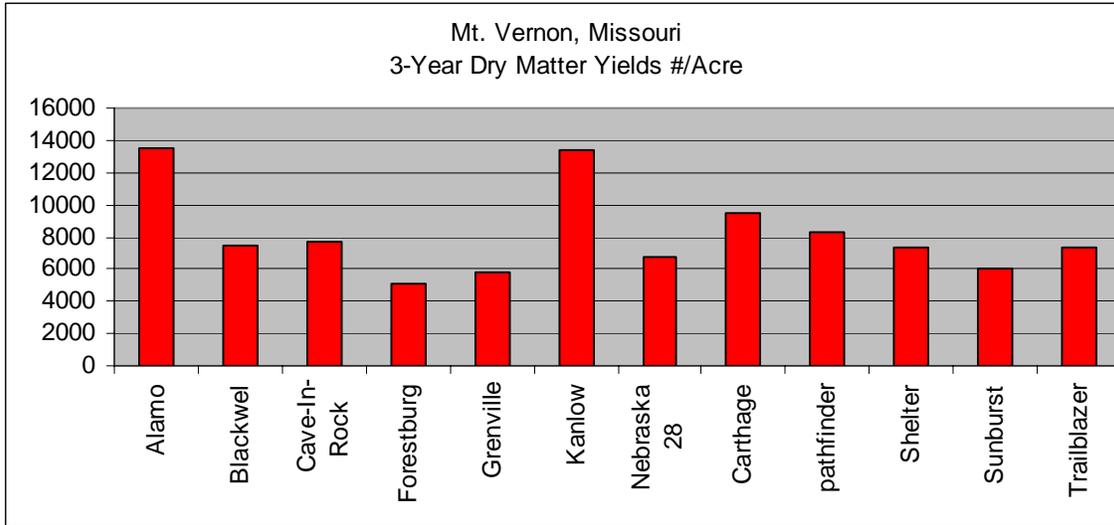
Collected from grasslands in Nebraska and Kansas. Trailblazer is similar to Pathfinder in maturity, appearance, and area of adaptation. It was selected for improved forage quality and the invitro dry matter digestibility is greater than Pathfinder. Trailblazer was released by the USDA Agricultural Research Service and the University of Nebraska Department of Agronomy.



Summary of Results

| | Cedar Falls, Iowa North Location | Perry, Illinois Central Location | Mt. Vernon, Missouri South Location |
|--|---|--|--|
| Switchgrass | | | |
| Best Varieties Biomass Yields range, 6-7 tons/acre | Kanlow | None | Alamo Kanlow |
| Better Varieties Biomass Yield range, 5-6 tons/acre | Blackwell Shelter Carthage | None | None |
| Good Varieties Biomass Yield range, 4-5 tons/acre | Alamo Trailblazer Pathfinder Cave-in-Rock Sunburst Nebraska 28 | Kanlow Alamo Blackwell Cave-in-Rock | Carthage Pathfinder Cave-in-Rock |





Results and Discussion

Biomass yields at all locations were dependent on seasonal precipitation patterns. Seed origin is also critical in overall performance. Previous studies at the Bismarck PMC have shown that generally, warm-season grass species can be moved about 300 miles north or 200 miles south of their original collection location. East and west movement is affected by moisture and elevation (USDA, NRCS 2006).

Grenville, a New Mexico variety and coming from an elevation of 800mm (4938 feet), and Forestburg, from South Dakota, the northern most variety ranked lowest in three year average biomass yield at all three sites. Varieties producing the most biomass varied across the plot locations, but generally, the more southern origin varieties produced the most biomass.

Switchgrass is a species with a broad range of adaptation. Alamo and Kanlow were the two highest yielding varieties for dry matter yield except Alamo yields decline at the northern location. At the northern location, Blackwell and Shelter followed Kanlow. Carthage is a variety of eastern origins but is not on the commercial market at this time. It looked very good at all three locations and stays green longer in the fall. Cave-In-Rock and Pathfinder looked good at all their locations.

Alamo and Kanlow are the latest maturing varieties at each location, except Carthage is later than Alamo at the central location. Pathfinder, Cave-In-Rock and Blackwell are all within about a week at all locations.

Percent stand is an indication of how quickly the variety/selection established and how well it maintained itself. Warm season species generally establish slower than cool season species. A warm season planting should be useable the second growing season and be in full production by the third.



Origin of varieties

Alamo - USDA-NRCS-. PMC Knox City, TX. Origin Frio River South Central TX

Blackwell-USDA-NRCS-PMC Manhattan, KS. Origin Blackwell, OK North Central OK

Carthage -USDA-NRCS-PMC-Cape May NJ.. Origin Central NC.

Cave-In-Rock- USDA-NRCS- PMC Elsberry MO. Origin Southern IL near Cave-in-Rock IL. in Hardin Co., IL

Forestburg -USDA-NRCS-PMC Bismark, Origin Sanborn Co., near Forestburg, SD. East Central, SD

Grenville-USDA-NRCS-PMC Albuquerque, NM, Origin Grenville NM. North east NM.

Kanlow USDA-NRCS-PMC Manhattan, KS, Origin Wetumka, OK East Central OK.

Nebraska 28 -USDA-ARS Holt Co., NE, NRCS-NEAES North Central NE, Origin in Holt County, NE.

Pathfinder- USDA-ARS KS and NE, Lincoln, NE, Origin collections from NE. and KS.

Shelter-USDA-NRCS-PMC Big Flats, NY, Origin St. Marys, WV.

Sunburst- SD State University ,Brookings, SD. Origin of collection near Yankton, SD. Southeast SD.

Trailblazer- USDA-ARS KS and NE., NEAES Lincoln, NE, Origin of collections from KS. and NE.

Key Establishment and Management Considerations

- **Soils/Adaptation:** Plant performance is best on moderate to fine textured deep soils in areas of greater than 14 inches of average annual precipitation.
- **Seeding:** Switchgrass is a small, smooth seed with approximately 259,000 seeds per pound, (Source plants.usda.gov database).

The Missouri NRCS recommended drilled seeding rate for switchgrass is 5.9 pounds per acre as a pasture and hayland seeding rate (USDA, NRCS 2007). Rates are calculated on Pure Live Seed (PLS). The recommended broadcast seeding rate is 1.50 times the recommended drill rates. Seeding rates vary across the United States, generally increasing from west to east. The recommended seeding rate is 10 PLS pounds per acre in the southeastern United States (USDA, NRCS 2006b). Spring or fall dormant seeding dates are recommended. A firm seedbed is essential for a shallow seeding depth (1/4 inch). Studies have shown an average germination of 65 percent when planted 1 inch deep, and zero germination when planted 2 inches deep (USDA, NRCS 2003).

- **Weed Control:** Abundant broadleaf weeds and annual grasses need to be controlled by mowing and/or herbicide application. Young plants of annual foxtails (*Setaria* species) look very similar to switchgrass seedlings. Dense stands of foxtail can be very competitive and significantly reduce stand establishment. Herbicides generally are more effective than mowing in controlling annual grasses.
- **Grazing/Haying:** Palatability and digestibility of switchgrass are good for beef livestock when harvested in the early boot stage. Allow for 8 inches of stubble in early summer and 12 inches in late summer (USDA, NRCS 2006b).
- **Mowing:** Switchgrass has an elevated growing point. A mowing height of less than 6 inches in late spring or early summer may reduce stand density. Boe (2005) recommends delaying harvest until late summer or early fall for stand longevity and stable long-term biomass production.
- **Phytotoxicity:** Switchgrass is reported to be toxic to horses, sheep, and goats when grazing pure stands. The toxicity can cause photosensitivity and affect internal organs and liver function (USDA, NRCS 2002). No problems have been noted for cattle.
- **Fertilization:** Biomass quality and yield, and seed production can be improved with nitrogen application. A soil test is recommended to achieve maximum productivity.
- **Burning:** Switchgrass benefits from burning of plant residues prior to initiation of spring growth. Advantages include low impact residue removal; weed control; more uniform growth initiation and seed ripening; improved nutrient recycling; and more vigorous growth.
- **Seed Harvest:** Seed shattering may occur shortly after the first seed is ripe. Conventional grain harvesting equipment can be used with proper setting adjustments. Seed is subject to heating. Fields should be as weed free as possible prior to harvest. Many weed seeds (especially foxtails) are similar in size and shape to switchgrass and can be difficult to remove during the cleaning process.



References

Boe, Arvid. 2005. Adaptation and survival of switchgrass in South Dakota. *In* Northland News 2004/2005, USDA, NRCS Plant Materials Center, Bismarck, ND. p. 13-14.

USDA, NRCS Elsberry Plant Materials Center. 1994-1998 Technical report.

USDA, NRCS. 2002. Switchgrass toxicity/photosensitivity in horses, sheep, and goats. *In*: Northland News 2001/2002, USDA, NRCS Plant Materials Center, Bismarck, ND. p. 6.

USDA, NRCS. 2003. Five keys to successful grass seeding. Plant Materials Center, Bismarck, ND. 6p.

USDA, NRCS. 2006b. *The PLANTS Database*, National Plant Data Center, Baton Rouge, LA 70874-4490 Available at: <http://plants.usda.gov>. Accessed 18 December 2006.

USDA, SCS. 1994. Grass varieties in the United States. Agric. Handbook No. 170. Washington, D.C. p. 194-199.

USDA, NRCS 2007. Missouri 723 Standard, Vegetation Establishment, Herbaceous Seeding.

