K-STATE
Research and Extension

Kansas Switchgrass Production Handbook

Kansas State University
Agricultural Experiment Station
and Cooperative Extension Service

Contents

History

Switchgrass (*Panicum virgatum* L.) is a warm-season perennial grass indigenous to the North American tall-grass prairie but is widely distributed throughout the continent (Figure 1). Switchgrass was identified by the U.S. Department of Energy as a leading potential cellulosic bioenergy crop due to its large biomass production and wide range of geographical adaptation.

The U.S. Energy Independence and Security Act of 2007 mandated fuel producers use at least 36 billion gallons of biofuel by 2022. As part of this mandate, more than $1 billion was allocated to advance the development of cellulosic ethanol made from switchgrass, wood chips, crop residues, and other nongrain sources.

The recent incentives to develop cellulosic ethanol have generated interest in growing switchgrass as an alternative crop. Switchgrass has the potential to be grown across Kansas to meet this emerging demand, and might be better suited to marginal land than some currently grown crops.

Uses

In addition to use as a feedstock for bioenergy, switchgrass traditionally has been used for livestock forage, soil stabilization, and wildlife cover. Switchgrass was widely used alone or in combination with other warm-season grasses in programs such as the Soil Bank and Conservation Reserve Program to reseed cropland. Other conservation uses of switchgrass include seedings along roadsides, in waterways, and various right-of-way situations.

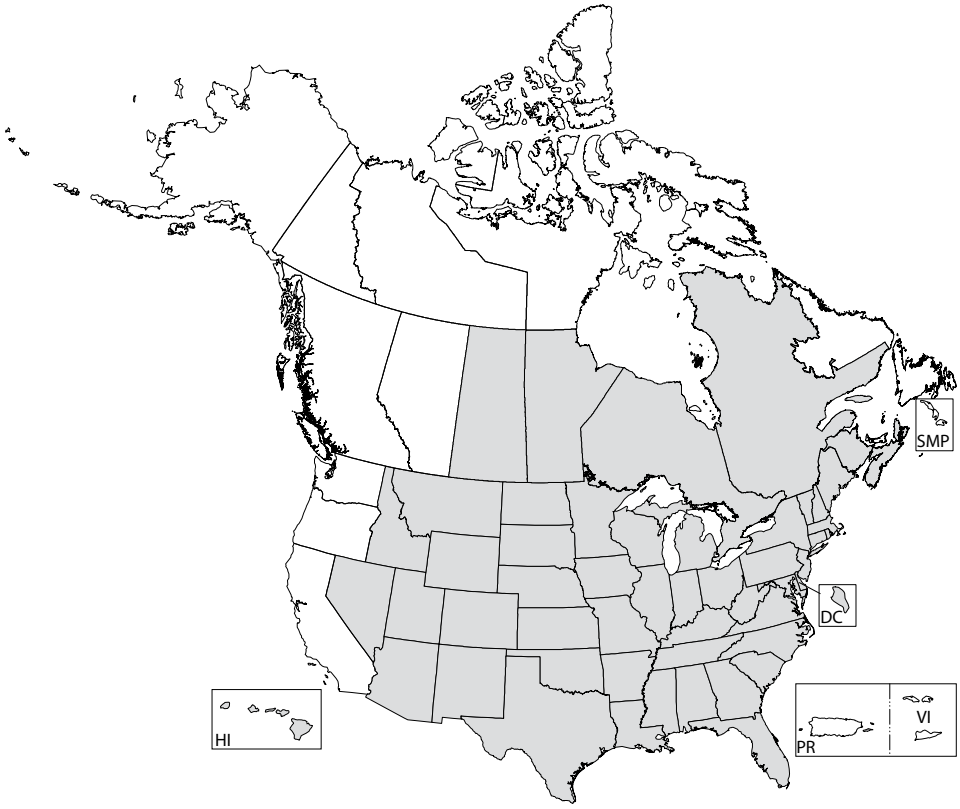
Switchgrass's high biomass production and rapid perennial growth make it a good cellulosic crop. The objective of a cellulosic crop is to convert as much solar energy as quickly and efficiently as possible into an organic energy source, primarily cellulose. Cellulose is a polysaccharide (a long-chain carbohydrate composed of simple sugars) of glucose that makes up most of the plant cell wall that can be liquefied, gasified, or burned directly to produce energy.

Cellulose can be used to make electricity, produce cellulosic ethanol, or heat homes and businesses. With today's technology, 1 ton of baled switchgrass can produce about 65 to 90 gallons of ethanol (Tvedten et al., 2001). In Kansas, this equates to about 450 gallons of ethanol per acre from an established stand that is not limited on moisture or fertilizer.

Like other warm-season grasses, switchgrass is a good summer forage source for beef cattle and can be used for grazing or hay production. Earlier maturing than most warm-season grasses, switchgrass is best used for grazing by early July.

Switchgrass pastures produced more pounds of beef per acre than other seeded grass mixtures or monocultures in a 10-year grazing study in western Kansas (Launchbaugh, 1971). Switchgrass is nutritious up to the boot stage of growth, with about 15

Figure 1. Switchgrass current distribution map.



Source: United States Department of Agriculture, Natural Resources Conservation Service Plants Database.

percent crude protein and 70 percent digestible dry matter. After the boot stage, forage quality rapidly decreases to about 4 percent crude protein and 40 percent digestible dry matter.

Under ideal growing conditions in the Midwest, switchgrass produces roots up to 10 feet deep and grows up to 10 feet tall. In western Kansas, irrigated switchgrass grows up to 7 feet tall. These characteristics make it ideal as a grass filter strip for controlling water and nutrient runoff and soil erosion.

Growth Characteristics

When grown from seed, switchgrass is slow to establish because seedling vigor is low compared to annual crops. Its biomass production is not maximized until the second or third year after seeding. Under dryland conditions in a western Kansas grazing system, switchgrass reached peak production approximately 5 years after seeding (Launchbaugh, 1971).

Switchgrass initiates growth in the spring and continues through the summer if moisture is available. Switchgrass develops small to large sodded clumps and spreads slowly from rhizomes (underground stems). Switchgrass's deep rooting potential helps it tolerate moisture stress, but it does best in areas with greater than 20 inches of annual precipitation.

Two ecotypes of switchgrass, classified as either lowland or upland, naturally evolved over time through adaptation to local growing conditions. Lowland types tend to grow taller, up to 10 feet, are coarser stemmed, and have faster growth rates than upland types. Lowland types tend to form a bunch-type growth pattern and are best suited for heavier, wetter soils. Upland types tend to be shorter, to be finer stemmed, and to form more of a sod type growth pattern. Upland types also are better adapted to moisture stress than lowland types.

Environmental Requirements

Switchgrass grows best in areas with at least 20 inches of annual precipitation. In sites that receive less than 20 inches, supplemental irrigation is recommended.

In central and eastern Kansas, switchgrass will establish stands and produce high yields with near normal precipitation. In western Kansas, however, irrigation will improve stand establishment and yield. Switchgrass can survive periods of drought, but yields will be greatly reduced. Spring moisture is more important in determining yield than late-season moisture, although the latter is important in maintaining a healthy stand and for producing yield the following year. Switchgrass might be well-suited to grow under limited irrigation in western Kansas.

Switchgrass grows well across a wide range of soil types but prefers well-drained, finer textured soils with a pH range of 5 to 8. A study conducted at the Southwest Research-Extension Center in Garden City demonstrated that some varieties were susceptible to iron chlorosis at a soil pH of 7.5. Of the cultivars evaluated, Cave-in-Rock and EXP-58 showed the most susceptibility to iron deficiency, while Alamo, Blackwell, EXP-54, Kanlow, and Trailblazer showed the least susceptibility (Table 1). Although iron chlorosis did not reduce yield in this study, some varieties may have reduced yields when soil pH is higher than 7.5. Susceptible varieties are not recommended when planting on soils with a pH of 7.5 or greater.

Cultural Practices

One of the keys to a good, long-lasting stand is management during the establishment year. Factors influencing stand establishment are seeding rate, planting depth, planting date, soil moisture, and weed control. Well-managed stands can be productive for more than 15 years.

Field Preparation

Switchgrass can be established in both conventional-till and no-till systems. The stand should be planted into a firm, weed-free seedbed with a minimal weed seed bank. In no-till situations, a burn-down herbicide, such as glyphosate, applied just before or at the time of seeding can effectivly delay weed competition. Avoid planting into an area known to have problematic grass weeds since few selective grass herbicides are available. Standing crop residue provides an excellent seedbed by modifying the microclimate (increased soil moisture and reduced air temperature) near the soil surface, and should be viewed as a requirement for dryland establishment in semi-arid climates like western Kansas.

Seeding Date

Switchgrass germinates at soil temperatures warmer than 50 degrees Fahrenheit. Seedling vigor is best when soils reach 65 degrees Fahrenheit and air temperatures reach 75 to 85 degrees Fahrenheit.

Table 1. Switchgrass iron chlorosis ratings, Southwest Research-Extension Center in Garden City, 2007-2009.

Cultivar [1]	2007	2008 [2]	2009	Cultivar average [3]
		Chlorosis [4]		
Alamo	1.7^{bc}	-	0.8^{dc}	0.8^{cd}
Blackwell	2.0^{bc}	-	0.2^{e}	0.7^{cd}
Cave-in-Rock	8.0^{a}	-	1.8^{a}	3.3^{a}
EXP-54	2.0^{bc}	-	0.2^{e}	0.7^{cd}
EXP-55	3.3^{bc}	-	0.3^{de}	1.2^{bc}
EXP-56	3.7^{b}	-	1.5^{ab}	1.7^{b}
EXP-57	2.3^{bc}	-	1.0^{bc}	1.1^{bc}
EXP-58	8.0^{a}	-	1.3^{abc}	3.1^{a}
Kanlow	2.0^{bc}	-	0.0^{e}	0.7^{cd}
Trailblazer	0.7^{c}	-	0.2^{e}	0.3^{d}
$LSD_{0.05}$ [5]	2.7	-	0.7	0.8
Year Average	3.4^{a}	-	0.7^{b}	1.4
Type				
Lowland				1.0^{b}
Upland				1.8^{a}
$LSD_{0.05}$				0.6

[1] Exp. denotes an experimental cultivar.
[2] No chlorosis was observed in 2008.
[3] Average across years.
[4] 0 = no chlorosis and 10 = severe chlorosis.
[5] Means followed by different letters are statistically different at the $P<0.05$ level.

With adequate soil moisture and warm soil temperatures, emergence can occur in as little as 3 days with most seed emerged within 14 days. To ensure successful establishment, the soil should remain moist for one month after emergence. A stand of at least one plant per square foot at the beginning of the second year is considered successful establishment. Over time, thin stands can fill in as long as the initial stand is adequate. In Kansas, optimum switchgrass planting dates range from March 25 to April 30.

Method and Rate of Seeding

Seed should be planted ¼ to ½ inch deep with 5 to 10 pounds pure live seed per acre. The higher rate should be used under less-than-ideal growing conditions or when the seed is broadcast rather than drilled.

Switchgrass has a smooth, round seed, which flows easily, allowing it to be seeded with conventional-till drills, no-till drills, or a broadcast spreader. Ensure good seed-to-soil contact for good seed germination, using some sort of packer if needed. Broadcast spreaders with a large packing wheel or individual rows with press wheels should both be adequate to create a firm seedbed as long as they are adjusted properly.

In areas with greater precipitation or under irrigation, switchgrass has been seeded successfully with corn as a companion crop. This practice capitalizes on the corn herbicide program to prevent early weed competition and the corn canopy to shade late weed competition, without reducing switchgrass stand density (Hintz et al., 1998). Follow herbicide labels for both corn and switchgrass if planting switchgrass the same time as corn.

As with many perennial grasses, switchgrass seed is in a natural dormant state when initially harvested. This dormancy needs to be broken before it will germinate. Methods used to break dormancy are letting the seed age for 1 to 2 years after harvest, or seed stratification. Stratification is the process of exposing the seed to moist, cold conditions, and can be achieved by planting seed during the spring freeze-thaw period or moistening the seed and storing it at 41 to 50 degrees for 1 month before planting. Planting early during cool weather, however, can lead to problems with cool-season weed competition.

Cultivar Selection

An important consideration when selecting a cultivar of switchgrass is its latitude of origin. Studies have shown a strong correlation between latitude of origin and yield potential. Southern

Table 2. Switchgrass cultivar, type, source, and origin.

Cultivar	Type	Source	Origin
Alamo	Lowland	USDA-NRCS Plant Material Center, Knox City, Texas	south central Texas near Frio River
Blackwell	Upland	USDA-NRCS Plant Material Center, Manhattan, Kan.	north central Okla. near Blackwell
Carthage	Upland	USDA-NRCS Plant Material Center, Cape May, N.J.	central N.C.
Cave-In-Rock	Upland	USDA-NRCS Plant Material Center, Elsberry, Mo.	southern Ill. near Cave-in-Rock
Dacotah	Upland	USDA-NRCS Plant Material Center, Bismarck, N.D.	south central N.D. near Breien
Forestburg	Upland	USDA-NRCS Plant Material Center, Bismarck, N.D.	east central S.D. near Forestburg
Kanlow	Lowland	USDA-NRCS Plant Material Center, Manhattan, Kan.	east central Okla. near Wetumka
Nebraska 28	Upland	USDA-ARS, NRCS and Neb. Agricultural Experiment Station	northeastern Neb. in Holt County
Pathfinder	Upland	USDA-ARS Kan. and Neb. / Neb. Agricultural Experiment Station	collections from Neb. and Kan.
Shelter	Upland	USDA-NRCS Plant Material Center, Big Flats, N.Y.	north central W.Va. near St. Marys
Sunburst	Upland	South Dakota State University, Brookings, S.D.	south east S.D. near Yankton
Trailblazer	Upland	USDA-ARS Kan. and Neb. / Neb. Agricultural Experiment Station	collections from Kan. and Neb.

cultivars tend to yield more as they are moved slightly north, but a cultivar planted too far north might not survive the winter. The opposite is true when moving a northern cultivar south. Northern cultivars tend to yield less as they are moved south, in part because they will tend to mature earlier than southern cultivars and will have fewer days for growth and accumulating biomass before seed set. When selecting a variety, try to select a variety that originated within 300 miles to the north or south of your location (Table 2).

Precipitation level or the ability to irrigate also should be considered when selecting a variety. If moisture is not limiting, a lowland type will produce higher yields, but if moisture is limiting, an upland variety will likely perform best.

Fertility

Nitrogen fertilization during the establishment year is not recommended since switchgrass growth is too slow to efficiently use nitrogen, and excessive nitrogen will increase weed competition. Phosphate and potassium fertilization should be applied before seeding, based on soil test recommendations.

Nutrient management in switchgrass depends on the purpose and management of the grass. Historically, little fertilization took place because switchgrass was thought to not respond significantly to fertilizer.

In recent years, however, this perspective has changed. Nutrient management of switchgrass should consider the intended use, the desired quality, the potential for nutrient uptake and removal, and the response of applied fertilizer. If the grass is used for livestock consumption, it may be advantageous to supply additional fertilizer, specifically nitrogen, to increase forage production and boost nitrogen content and thus protein.

Switchgrass can maintain respectable productivity by cycling nitrogen from the shoots to its crowns and roots at the end of the growing season, even with little or no fertilizer. If the switchgrass is used as a cellulosic biomass crop, nutrients in the biomass will be removed from the field — although if harvested after a killing freeze some of the nitrogen will be cycled from the shoots to the crown and roots for over-winter storage. Whether harvested for livestock or biomass use, those nutrients removed should be replaced to maintain productivity.

Data from southern Oklahoma suggest switchgrass may respond to nitrogen rates up to 160 pounds per acre, but other data suggest the application of up to about 130 pounds per acre. Higher rates of nitrogen were shown to increased subsequent year's yield even when switchgrass was harvested after a frost. Clearly cultivar and environmental variations cause different responses to nitrogen rate.

Although nitrogen responses have been reported at rates up to 160 pounds per acre, most sources agree that about 70 pounds per acre per year is the most economical application rate. If switchgrass is harvested in the vegetative stage, apply 30 pounds of

nitrogen per acre for every ton of biomass removed per acre (NRCS, Technical Guidance Number 23). If switchgrass is harvested for biomass after a killing freeze, nitrogen rates can be reduced to about 15 pounds of nitrogen per acre for every ton of biomass removed per acre. Nitrogen should be applied within 2 weeks of spring greenup to ensure adequate early season plant growth and to prevent nitrogen loss. In addition, proper timing of nitrogen application will reduce weed competition by minimizing nitrogen uptake by weeds.

As nitrogen rates and switchgrass yields increase, phosphorus and potassium removal rates will also increase. When switchgrass was harvested after a frost and nitrogen rate was 160 pounds per acre, phosphorus and potassium removal rates increased by 71 and 31 percent, respectively, compared to no nitrogen application. As a result, without additional applications, the soil will be depleted of phosphorus and potassium.

Weed Control

Weed competition can make switchgrass establishment challenging. Many weed species germinate earlier than switchgrass and vigorously compete for moisture, sunlight, and nutrients. It is essential to start with a weed-free field before planting since few herbicides are labeled for use in switchgrass.

Currently, two herbicides are registered in Kansas for preemergence application in switchgrass establishment. Metsulfuron (e.g. Escort XP) at 0.1 ounce per acre and quinclorac (e.g. Paramount) at 5.3 to 8.0 ounces per acre have foliar activity on emerged weeds and will provide residual control of susceptible weed species. Glyphosate or paraquat also can be used to control weeds in the seedbed before grass germination and emergence.

If weed pressure is a problem during the establishment year, mowing two or three times can help keep weeds under control and allow switchgrass to establish. Mow the weeds to the height of the switchgrass, but take care not to defoliate switchgrass. Flash grazing when weeds are small and palatable may provide some weed control, but must be done without significant use of the grass. Minimizing defoliation allows the switchgrass seedling maximum photosynthesis to get established. Avoid mowing once switchgrass stems start to elongate. Established stands have minimal weed problems due to extensive competition from switchgrass.

Only a handful of herbicides are registered for weed control in established switchgrass. Sulfosulfuron can be applied to switchgrass having three leaves and may control some broadleaves and annual grasses. Paramount may be used at 5.3 to 8 ounces per acre as an early postemergence treatment for weed control in newly planted switchgrass or may be tank mixed with other labeled herbicides to improve the spectrum of weeds controlled. Dicamba or metsulfuron can be applied to switchgrass after the three-leaf stage for early broadleaf weed control. Herbicides registered for use in Conservation Reserve Program (CRP) fields will generally be safe on switchgrass. A list of the herbicides can be found in the Kansas State University publication *Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland*. Be sure to read and follow herbicide labels.

Fire can be used on switchgrass plantings as early as the year after seeding. Burning when switchgrass has just emerged in spring with 1 to 1.5 inches of growth, can stimulate tillering, remove mulch, and provide some annual weed control.

Diseases and Their Control

The most common disease problem on switchgrass is leaf rust (*Puccinia* spp.). Lowland types are generally more rust resistant. The best management practice is to select the best adapted cultivars available for the area or select resistant cultivars if available.

Insects and Their Control

Research on the insect pests of switchgrass is limited. Major insect problems should not be anticipated initially. With intensive production, pest problems could develop. Opportunistic general feeders such as grasshoppers or general grass feeding insects such as aphids and leafhoppers could cause plant injury at any time.

The "switchgrass moth," *Blastobasis repartella*, was recently reported as a pest of switchgrass in South Dakota. Larvae of this moth feed on young tillers of switchgrass. This moth is an example of an insect that was first identified years ago and evidently existed at sub-economic levels in the region for years. It has only recently been identified as a pest on switchgrass on a private farm specializing in seed production of native grasses. If switchgrass production increases, further

study would be warranted to monitor for possible pests and develop management plans after potential pests are identified.

Harvesting

Switchgrass is harvested in the same manner as other hay, using the same equipment. In fields with high yields, small swathers may be inadequate to handle the tonnage, and windrows may be too large for smaller baling equipment. In these cases, adjustments to cutting methods such as hiring a custom harvester or cutting with less than a full header width might be necessary.

Cellulose Harvesting

Harvesting switchgrass for cellulose is primarily done once a year, 2 to 3 weeks after a killing frost and before green up in the spring. This allows some nutrients in the shoots to be translocated into the crowns and roots for overwinter storage, to improve winter survival, and to increase stand life. Harvesting early after a killing frost results in higher yields and better quality biomass.

Overwintering before harvest can result in a 20 to 30 percent yield loss from the breakage and dropping of plant parts, however, many constituents useful for energy production still remain. Leave a stubble height of 4 to 6 inches to reduce the risk of crown injury and help trap snow to insulate the crown during cold weather.

Moisture content should be less than 15 percent for baling and storing without spoilage. If spoilage occurs, the feedstock quality will be reduced. Harvesting first-year switchgrass stands for biomass is possible if establishment was successful; however, expected yields are 30 to 40 percent of yields from mature stands.

Forage Harvesting

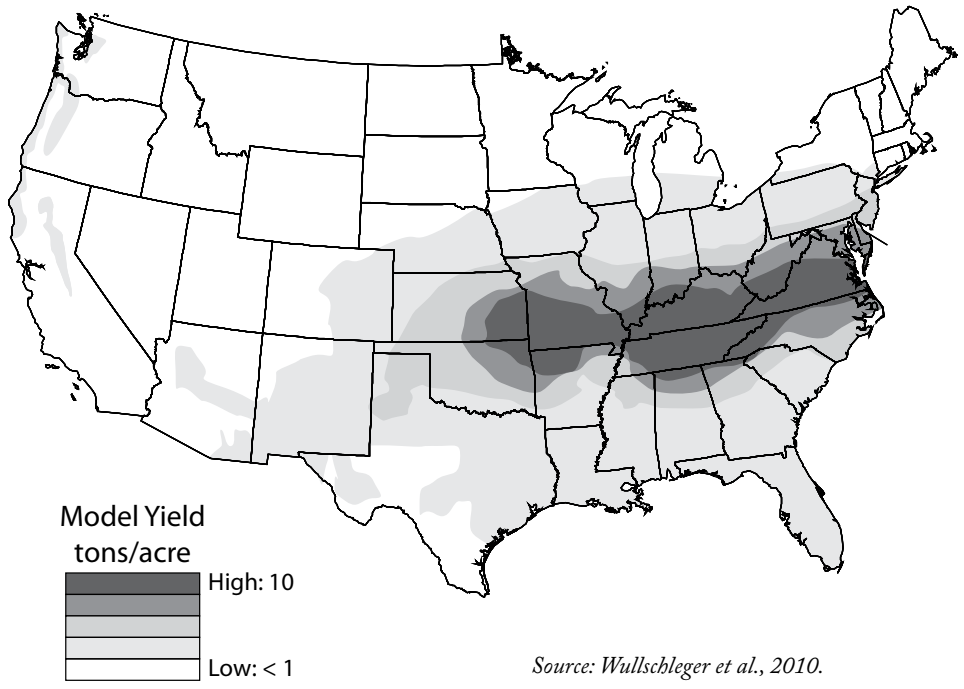
Harvesting switchgrass for forage can be done either by haying or grazing. Management of switchgrass for forage production differs from that for cellulose production. First, to ensure that the plant establishes and has adequate root reserves for overwintering, the stand should not be heavily grazed or hayed the first year. With careful management, first-year stands can be flash grazed without negative effects on second-year stands (Launchbaugh 1971).

Second, the ideal time for forage removal is late spring when plant height has reached 12 inches; at this stage, the grass has stored enough energy to tolerate defoliation and regrow without depleting energy reserves, and forage quality will be optimized. In grazed stands, forage quality rapidly declines and dry matter rapidly accumulates with the onset of stem elongation. Flexibility in stocking density could be helpful to utilize forage before it gets too mature. Try to leave 6 inches of stubble height after grazing or haying to ensure that the plants have enough leaf area for photosynthesis and regrowth. Every few years, rest the stand from mid- to late summer until dormancy to help maintain the stand.

Switchgrass Yields in Kansas

Switchgrass yielded up to 7 tons per acre in eastern Kansas (Table 3). Yields in western Kansas under irrigation will be similar to those in eastern Kansas, but without irrigation, yields will be 2 to 4

Figure 2. Estimated yields of switchgrass across the United States.



Source: Wullschleger et al., 2010.

tons per acre. Figure 2 displays modeled expected switchgrass yields across the United States based on precipitation and temperature. Eastern Kansas is considered to be in one of the highest-yielding areas. Although the modeled yield for eastern Kansas approaches 10 tons per acre, actual yield results were closer to 7 tons per acre.

Table 3. Switchgrass dry matter biomass yield between 2007 and 2009 at the Southwest Research-Extension Center (SWREC) in Garden City and the Southeast Agricultural Research Center (SEARC) in Mound Valley.

Location	Cultivar	2007	2008	2009	Cultivar average [1]
		Yield (lb/acre)			
SWREC	Alamo	2,502[a]	13,108[ab]	14,504[a]	10,038[a]
	Blackwell	1,736[a]	11,225[bc]	10,307[b]	7,756[d]
	Cave-in-Rock	2,490[a]	10,253[bc]	9,779[b]	7,507[d]
	EXP-54	1,875[a]	11,328[abc]	13,039[a]	8,748[c]
	EXP-55	2,324[a]	14,130[a]	13,575[a]	10,010[a]
	EXP-56	2,719[a]	12,750[ab]	13,684[a]	9,718[ab]
	EXP-57	3,206[a]	11,632[abc]	14,881[a]	9,907[ab]
	EXP-58	2,236[a]	9,044[c]	9,240[b]	6,840[d]
	Kanlow	1,697[a]	12,056[ab]	13,193[a]	8,982[bc]
	Trailblazer	1,681[a]	10,473[bc]	9,919[b]	7,358[d]
	$LSD_{0.05}$ [2]	1,048	2,875	2,533	968
	Year Average	2,247[b]	11,600[a]	12,212[a]	8,686
	Type				
	Lowland				9,567[a]
	Upland				7,365[b]
	$LSD_{0.05}$				514
SEARC	Alamo	6,948[b]	14,455[ab]	12,351[bc]	11,251[a]
	Cave-in-Rock	4,743[de]	9,275[c]	8,469[e]	7,496[c]
	EXP-54	6,443[bc]	14,152[ab]	13,417[ab]	11,337[a]
	EXP-55	6,927[b]	13,759[b]	13,466[ab]	11,384[a]
	EXP-56	8,383[a]	13,277[b]	11,975[bc]	11,211[a]
	EXP-57	6,399[bc]	13,821[b]	10,594[dc]	10,271[b]
	EXP-58	4,122[e]	9,634[c]	8,885[de]	7,547[c]
	EXP-59	6,311[bc]	15,758[a]	12,264[bc]	11,444[a]
	EXP-60	8,216[a]	14,179[ab]	11,810[bc]	11,401[a]
	Kanlow	5,660[cd]	14,537[ab]	14,254[a]	11,483[a]
	$LSD_{0.05}$ [2]	1,243	1,693	1,846	764
	Year Average	6,415[c]	13,284[a]	11,748[b]	10,482
	Type				
	Lowland				11,223[a]
	Upland				7,521[b]
	$LSD_{0.05}$				574

[1] Average across years.
[2] Means followed by different letters are statistically different at the $P<0.05$ level.

Economics of Production and Markets

Switchgrass production information and budgets are shown in Tables 4 – 6 for southwest and southeast Kansas. Data for the production budgets came from research at the Southwest Research-Extension Center and the Southeast Agricultural Research Center in Table 3. The establishment year yield was the 2007 yield average and the full stand yield was the average yield from 2008 to 2009.

Returns over costs are negative for the establishment years in both southwest and southeast Kansas. In the full-stand phase of production, returns are negative in southwest Kansas, but positive in southeast Kansas. The reason returns were significantly lower in southwest Kansas is primarily due to irrigation costs — both fixed and variable. Yields were also slightly lower in southwest Kansas. Consequently, switchgrass may have a difficult time competing against higher-value crops such as corn, soybeans, and alfalfa, even under limited irrigation. Switchgrass may, however, compete more favorably with other crops in southeast Kansas where irrigation is not necessary.

Planting switchgrass is a long-term commitment with significant up-front investment costs requiring 2 to 3 years before potential profits are received. To improve economic viability, it is critical to secure a long-term market for biomass before establishing switchgrass and to use best management practices for stand establishment.

Table 4. Production inputs per acre for the establishment and full stand production phases of switchgrass production in southwest and southeast Kansas.

Item	Southwest Kansas Establishment	Southwest Kansas Full stand	Southeast Kansas Establishment	Southeast Kansas Full stand	Cost/unit
Seed, lbs	7.5	0	7.5	0	$ 5.75/lb
Fertilizer, lbs					
N	0	167	0	175	$ 0.57/lb
P	0	40	0	40	$ 0.70/lb
Herbicide, oz[1]					
Escort XP	0.1	0	0.1	0	$ 10.56/oz
Glyphosate	32	0	32	0	$ 0.11/oz
Adjuvants	1	0	1	0	$ 1.00/a
Banvel	4	4	4	4	$ 0.42/oz
Irrigation water, in	6	12	0	0	$ 3.50/in

[1] See Kansas State University publication *Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland* for up-to-date herbicide control options.

Table 5. Machinery resources per acre for the establishment and full-stand production phases of switchgrass production in southwest and southeast Kansas.

Item	Southwest Kansas Establishment	Southwest Kansas Full stand	Southeast Kansas Establishment	Southeast Kansas Full stand	Custom rate
Machinery Operation					
Drill	1	0	1	0	$ 14.85
Fertilizer application	0	1	0	1	$ 5.05
Herbicide application	2	1	2	1	$ 5.13
Mowing	2	0	2	0	$ 12.60
Harvest					
Swathing	1	1	1	1	$ 12.18
Sideraking	1	1	1	1	$ 4.31
Baling (bales/a) [1]	1.5	7.9	4.3	8.4	$ 11.33

[1] Assumes big round bales weighing 1,500 pounds, without net – cost includes hauling to storage.

Table 6. Projected budgets for the establishment and full stand production phases of switchgrass production in southwest and southeast Kansas.

	Southwest Kansas Establishment	Southwest Kansas Full stand	Southeast Kansas Establishment	Southeast Kansas Full stand
INCOME PER ACRE				
A. Yield (ton) per acre	1.12	5.95	3.21	6.26
B. Price per ton	$66.50	$66.50	$66.50	$66.50
C. Net government payment	$32.53	$32.53	$11.39	$11.39
D. Indemnity payments	$0.00	$0.00	$0.00	$0.00
E. Miscellaneous income	$0.00	$0.00	$0.00	$0.00
F. Returns/acre ((A x B) + C + D + E)	$107.01	$395.68	$224.86	$427.68
COSTS PER ACRE				
1. Seed	$43.13	$0.00	$43.13	$0.00
2. Herbicide	7.26	1.68	7.26	1.68
3. Insecticide/Fungicide	0.00	0.00	0.00	0.00
4. Fertilizer and Lime	0.00	122.96	0.00	127.91
5. Crop Consulting	0.00	0.00	0.00	0.00
6. Crop Insurance	0.00	0.00	0.00	0.00
7. Drying	0.00	0.00	0.00	0.00
8. Miscellaneous	7.00	7.00	7.00	7.00
9. Machinery Expense	83.68	116.52	115.29	121.28
10. Non-machinery Labor	9.46	13.17	13.03	13.70
11. Irrigation				
a. Labor	6.50	6.50	0.00	0.00
b. Fuel and Oil	21.00	42.00	0.00	0.00
c. Repairs and Maintenance	1.98	3.96	0.00	0.00
d. Depreciation on Equipment	45.24	45.24	0.00	0.00
e. Interest on Equipment	39.10	39.10	0.00	0.00
12. Land Charge/Rent	62.00	62.00	48.00	48.00
G. SUB TOTAL	$326.34	$460.13	$23.70	$319.57
13. Interest on ½ Nonland Costs	6.30	10.98	6.50	9.51
H. TOTAL COSTS	$332.64	$471.11	$240.20	$329.08
I. RETURNS OVER COSTS (F-H)	$-225.63	$-75.43	$-15.34	$98.60

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Johnathon Holman
Cropping Systems Agronomist

Thomas Roberts
Assistant Scientist

Troy Dumler
Agricultural Economist

Walter Fick
Range Management Specialist

Robert Gillen
Rangeland Scientist

Keith Harmoney
Range Scientist

Kent Martin
Agronomist

Scott Maxwell
Agricultural Technician

Joseph L. Moyer
Research Agronomist

Phil Sloderbeck
Entomologist

Scott Staggenborg
Agronomist

Curtis Thompson
Weed Science Specialist

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