Herbaceous Biomass Production: *Switchgrass as a Potential Biomass Crop in Mississippi*

Traditional energy sources used in Mississippi include coal, natural gas, oil, and nuclear power. However, there is a growing interest in locally produced energy from renewable resources that can reduce dependence on energy from outside of Mississippi. Examples of renewable biomass crops include herbaceous species such as switchgrass, giant miscanthus, and energycane. These species have been widely studied because they can generate large amounts of biomass annually for potential conversion into various forms of energy.

Switchgrass (*Panicum virgatum*; **Figure 1**) is a perennial, warm-season, bunch-type grass native to North America. It was once a dominant species in the tall-grass prairie of the Midwest and could also be found in the South in lower, wetter sites and in historical grasslands like the Black Belt.

This species is divided into two ecotypes: upland and lowland. Upland ecotypes of switchgrass are typically found on dryer sites and are usually much shorter. Because they are short, they yield less biomass. Lowland ecotypes, however, are found in lower, wetter soils and are much taller. They yield more biomass. Stands of well-managed switchgrass have been known to produce for 10 to 20 years. This species is most productive on moderately well-drained soils with a pH of 5.0 or higher. Dry matter yields of the lowland ecotype range from 5 to 9 dry tons per acre. This amount of annual tonnage is what makes switchgrass an attractive crop for biomass production in Mississippi.

Figure 1. Switchgrass production field for bioenergy production. Dry biomass is harvested following senescence, allowing for optimum yields, low moisture, and minimal nutrient removal.

Currently, the alternative energy market in Mississippi is fairly limited. Decreasing natural gas prices and relatively moderate oil prices have slowed the push for alternative sources of energy. Southern yellow pine and other timber species are a $1.17 billion dollar industry in Mississippi and are often used for energy conversion. In Mississippi, loblolly pine is most often used for biomass. However, even though forests can generate a lot of biomass, herbaceous species will also be needed to keep up with the demand of conversion facilities. These facilities can process anywhere from 250 to 500 dry tons of biomass per day, producing several forms of energy, including drop-in liquid fuels, electricity from heat or steam, and ethanol.

Mississippi landowners can use switchgrass in other ways, too. Studies at Mississippi State University have identified switchgrass as a viable option for bedding in poultry production (Davis et al., 2010). Switchgrass was found to be no different than pine shavings, but chicken foot pad dermatitis was significantly decreased with switchgrass litter. Nearly 160 dry pounds of dry switchgrass are needed per cubic yard of poultry house space. Therefore, a 50-by-500-foot house layered 3.5 inches deep with bedding would require 262 tons of dry switchgrass biomass per house. With an average production yield of 7 dry tons per acre, 38 acres of one year's production would be needed to produce enough biomass for a single poultry house.

Increased demand for pelletized fuels for use in home heating units in the European Union has generated more production stateside. Several pellet mills in Mississippi are currently producing pellets from pine. Heating value of wood pellets ranges from 6,400 to 8,000 BTU per pound

with an average delivered production cost of $69 to $71 per ton; switchgrass pellets have a heating value of 7,120 to 8,000 BTU per pound with an average delivered production cost of $77 to $102 per ton (Gonzalez et al., 2011).

Switchgrass has also been used quite extensively for forage production. Several grazing studies across the Southeast have shown significant advantages in using this species as a forage crop. It has been shown to have increased drought tolerance, low fertilizer requirements, and good animal performance. Switchgrass should be grazed early in the growing season, as animal intake and forage quality drastically decrease as the plant reaches maturity. For more information on grazing management, refer to Extension Publication 2843 *Native Warm-Season Grasses as a Forage in Mississippi: Grazing Management*. Switchgrass can also be planted for wildlife habitat creation: when mixed with other native warm-season grasses, it provides excellent cover for ground nesting birds and small mammals. It can also be planted in buffer strips for soil and water conservation.

Site Preparation

There are several steps to successful establishment of switchgrass and high biomass yields. The first is site preparation. Once you have selected a site, determine what type of weed control is needed before sowing. In Mississippi, switchgrass is often considered for production on abandoned pastures or fields with marginal soils and a broad array of weeds to control. These sites often require at least one summer of repeated weed control before sowing. Sod grasses, such as bermudagrass, bahiagrass, or tall fescue, are somewhat difficult to control, and they require more attention to herbicides for effective control (**Figure 2**).

The first step to eradicate these sod grasses is to burn, hay, or graze as close to the ground as possible. Allow the regrowth to reach 4 to 5 inches, and then apply the herbicide if no other stress is present. Boomless applicators are not recommended due to their large drop sizes and irregular spray patterns. Small droplets and uniform spray patterns are better at completely covering the numerous small leaves and stolons of sod grasses. Multiple herbicide applications may be necessary for complete control. Herbicides for preplant weed control before planting can be found in **Table 1**. Always follow labeled recommendations and follow proper safety protocols when handling and applying herbicides. If you use prescribed burning to remove existing vegetation, be extremely careful. Be sure to monitor environmental conditions and make sure a certified prescribed burn manager is on-site to conduct the burn. Contact your local Mississippi Forestry Commission (***www.mfc.ms.gov***) office for more information on conducting a prescribed burn.

Tillage is not recommended for establishment. Most switchgrass sites are abandoned fields or pastures that may have rolling or steep contours. If sod grasses are present, tillage will divide and distribute rhizomes and stolons throughout the field, causing future weed control issues.

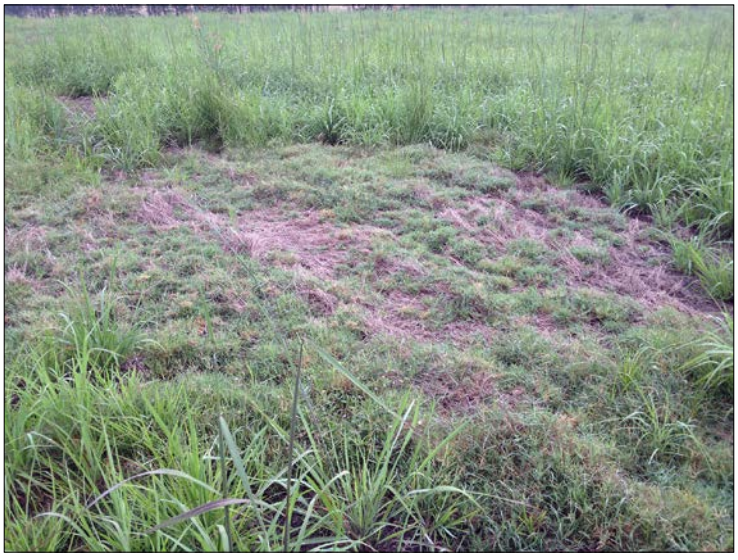

Figure 2. Uncontrolled sod grasses (like the bermudagrass pictured here) can eventually outcompete emerging switchgrass seedlings, robbing you of successful establishment.

Table 1. Recommended herbicides for switchgrass production.

Situation and active chemical per treated land acre*	Formulation needed for 1 acre treated broadcast	Time of application	Weeds controlled	Special instructions and remarks
Preplant				
Glyphosate	Glyphosate 4/5 lb/gal at 1.2/3 pt in 3–10 gal water plus 0.5–1% surfactant	To actively growing weeds	Tall fescue, annual broadleaf, grassy weeds	Multiple applications may be necessary to control newly emerged weeds.
Metsulfuron methyl	Escort, MSM60 at 0.5 oz in 3–10 gal water plus 0.5–1% nonionic surfactant	To actively growing weeds	Bahiagrass, annual broadleaf weeds	2–3 month replant interval on soils with pH 7.5 or greater.
Paraquat	Gramoxone Max at 0.75 pt/A of Boa 0.78 pt/A in 20 gal water	To actively growing weeds	Annual broadleaf and grassy weeds	Add 1 qt of nonionic surfactant per 100 gal of spray.
imazapyr	Arsenal, Polaris at 24 oz/A with nonionic surfactant	To actively growing weeds	Bermudagrass, several annual and perennial weeds, plus vines and undesirable woody plants	Do not apply more than 48 oz/A per year; 10–12 month plant back interval.
Preemergence				
atrazine	3.2 pt of a 4 lb/gal or 2 lb of 80% wettable powder or 1.78 lb of 90% WDF in a minimum of 10 gal of water for ground application	Preplant incorporated or preemergence at planting or prior to weed emergence	Ragweed, barnyardgrass, foxtail, little barley, marestail	Do not use on sand, loamy sand, or sandy loam or any soil with less than 1% organic matter. Do not graze or feed forage from treated areas for 21 days following application. Do not exceed 2 pounds of active ingredient per acre per year.
Postemergence				
2,4-D	1–2 pt in 10–20 gal water	To actively growing weeds	Annual broadleaf weeds	Wait until grasses are fully established before applying.
2,4-D + picloram	Grazon P+D at 1–8 pt/A or 1–2% solution in 20–40 gal water	To actively growing weeds	Most broadleaf weeds, woody brush, dogfennel, horsenettle	Wait until grasses are fully established before applying.
Aminopyralid + 2,4-D	Grazon Next at 1.5–2.6 pt in 20 gal water with nonionic surfactant	To actively growing weeds	Broadleaf weeds	Wait until grasses are fully established before applying.
Quinclorac	Paramount at 5.3–8.0 oz with methylated seed oil	To actively growing weeds	Crabgrass, foxtail, signalgrass, some annual broadleaf weeds	Only for use in little and big bluestem, switchgrass, and sideoats grama.
Nicosulfuron + metsulfuron methyl	Pastora at 1 oz with nonionic surfactant	To actively growing weeds fewer than 2 inches tall	Johnsongrass, vaseygrass, ryegrass, many broadleaf weeds	For use in switchgrass only.

*Adapted from Mississippi State University Extension Service Publication 1532 *Weed Control Guidelines for Mississippi.*

Tillage also increases the possibility of erosion and encourages weed seeds in the soil bank to germinate.

One effective way to control weeds in advance is to plant an herbicide-resistant crop, such as corn or soybeans. This will require several applications of a broad-spectrum herbicide for weed control in the crop and will generate revenue on the site during the year of weed control. Cool-season forage crops, such as cereal rye, ryegrass, and oats can also be sown in the fall as a smother crop, reducing the competition of summer grasses and broadleaf weeds into the spring. Leaving the dry, standing residue after the stand has matured can retain soil moisture, help cover the soil surface, and shade out germinating weed seeds between planted rows of switchgrass.

You should address soil fertility issues at the same time you address weed control (**Figure 3**). Take soil samples from the site and send them to the Mississippi State University Soil Testing Lab to find out about any deficiencies that may be present. Soil pH is the most important factor before planting. Switchgrass can tolerate soil pH of less than 6.0, but, as with most crops, better soil fertility leads to increased yields. Add lime before sowing if soil testing recommends it. If the soil tests low for phosphorous (P) or potassium (K), 40 to 60 pounds of P_2O_5 or K_2O is recommended annually to adjust levels back to medium. No nitrogen should be applied in the first year, or until weeds are controlled and the stand is fully established. If you apply nitrogen too early, emerg-

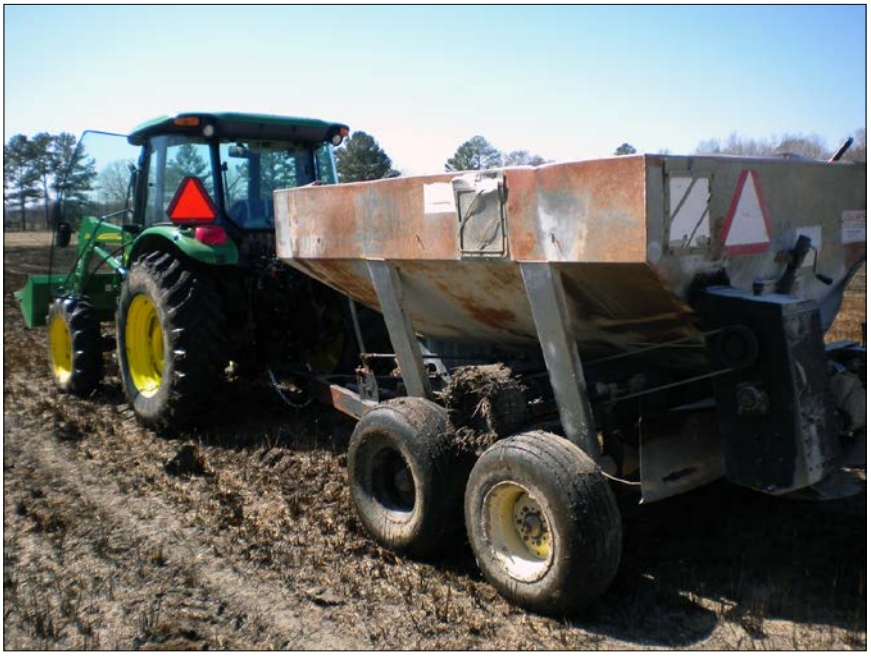

Figure 3. Managing soil fertility is essential for any crop production. Low soil pH can be corrected by applying lime before field establishment.

ing weeds will consume it, robbing you of production goals and increasing weed pressure.

Preemergent Weed Control

Preemergent weed control options for switchgrass are very limited. The only recommended preemerge herbicide for switchgrass is atrazine (**Table 1**). Atrazine can be applied just before planting or before weed emergence. Atrazine must be incorporated to be activated in the soil profile. Because tillage is not recommended, spraying should be done just before a rain of one-half inch or more. Weeds controlled by this herbicide include morningglory, foxtail, barnyard grass, pigweed, sicklepod, ragweed, and partial control of large (hairy) crabgrass.

Variety Selection, Seed Quality, and Planting Rate

There are only a few varieties of switchgrass available for biomass production in Mississippi. Lowland ecotypes are recommended for Mississippi because of their greater yields and their suitability for growing seasons and winters in the South. Varieties and seed sources can be found in **Table 2**. MSU forage variety testing assessed several well-known varieties for biomass yields at Newton and Starkville in 2013 (White et al., 2014). Consult MAFES Information Sheet 1363 *Mississippi Biomass Feedstock Variety Trials, 2013* for more information regarding results.

Table 2. Switchgrass variety origin and availability for Mississippi.

Variety	Origin of variety	Seed company/source*
Alamo	Texas	Roundstone, Ernst, Turner
BoMaster	North Carolina	Ernst
Cave-in-Rock	New Jersey	Ernst
Colony	North Carolina	Ernst
Expresso	Mississippi	Prairie Creek Seed
Kanlow	Oklahoma	Roundstone, Ernst
Kentucky Ecotype	Kentucky	Roundstone
Miami	Florida	Ernst
Performer	North Carolina	Ernst

*Roundstone Native Seed, LLC, 9764 Raider Hollow Rd., Upton, KY 42784; Ernst Conservation Seeds, 8884 Mercer Pike, Meadeville, PA 16335; Prairie Creek Seed, LLC, 5366 Reynolds Chapel Rd., Newbern, AL 36765; Turner Seed, 211 County Rd. 151, Breckenridge, TX 76424

Switchgrass seed is very small and, like most native grasses, is notorious for poor germination. However, with recent improvements in harvesting methods, combined with improved cultivars for agricultural production, seed quality has increased steadily over the years. Be sure to purchase seed from a reputable dealer who is known to produce

clean, quality seed. Before purchasing, ask for a copy of the seed label to ensure germination is greater than 70 percent.

Switchgrass should be planted at 6 to 8 pounds of pure live seed (PLS) per acre. Planting to PLS is a way of accounting for lower germination rates and purity. To calculate PLS, use the following equation:

% PLS = (germination % × purity %) / 100

Once you have figured out PLS, divide the desired rate (8 lbs/A) by % PLS, and multiply by 100. The resulting number is the amount of bulk seed to be planted per acre.

Planting

Planting can be accomplished using several different methods. The most effective is using a no-till drill with a small seed box. Most grass drills have a small seed box, or clover box, that is commonly used for establishing clovers or smaller grass seed for forage plantings. Switchgrass seed is just ⅒ of an inch in diameter (**Figure 4**). Trash plows or discs set in front of the planter units remove existing dead vegetation and create a micro-furrow where the seed is placed. Depth bands on the planter unit allow the seed to be placed at the appropriate depth of ¼ inch.

Figure 4. Switchgrass seed is extremely small (⅒ of an inch) and requires a planter with a small seed box and depth bands that prevent the seed from being planted too deeply.

Conventional planters, which require a prepared seedbed, can place the seed too deeply in loose soil, preventing germination and seedling development. However, if the seedbed is somewhat compacted, conventional planters can be used with a small seed box. Another planting method is broadcasting using a cone spreader. If this method is used, the seed should be mixed with a carrier, such as sand, lime, or crushed corn to aid in the distribution of the seed. Make sure the spreader is properly calibrated with the seed/carrier mix before sowing. After broadcasting, use a cultipacker to press the seed firmly into the soil surface, allowing the seed to reach moisture.

In Mississippi, planting dates range from late March to early June. Planting can take place after the threat of late-season frosts is over. Earlier planting helps ensure adequate spring moisture is available for germination and seedling development. Obviously, the later planting is delayed, the greater risk for dryer conditions. One risk in planting too early is not being able to control warm-season weeds. Delaying planting until after the first flush of summer weeds allows you to apply a burn-down herbicide just before establishment, giving you a greater window of reduced competition.

Postemergence Weed Control

Following planting, there are several herbicides that can be used for post-emergent weeds (**Table 1**). Broadleaf weeds can be controlled using any number of effective herbicides. These include 2,4-D, dicamba, triclopyr + fluroxpyr, or metsulfuron methyl.

However, for annual grass control, there are only two options for switchgrass. The first option is nicosulfuron + metsulfuron (Pastora). This product is registered for the control of grass and broadleaf weeds in Alamo switchgrass (**Table 1**). Applications can be made any time after the switchgrass has reached the two-leaf stage at a rate of 1 ounce per acre. A nonionic surfactant should be added to the mix. Yellowing or stunting is likely to occur in the establishment year, especially on younger plants (two- to four-leaf stage). No more than two applications are to be made per year (2 ounces per acre), with 16 days between applications. This product is effective at controlling these types of grasses:

- hard-to-manage annual grasses, such as broadleaf signalgrass, little barley, and large crabgrass;
- perennial grasses, such as johnsongrass and bahiagrass; and
- broadleaf species, such as pigweed, morningglory, and marestail.

The other option is quinclorac (Paramount; **Table 1**). This herbicide is labeled for weed control in fallow systems, grass grown for seed, wheat, and noncrop areas. Quinclorac can be applied at 5.3 ounces per acre for control of these grasses:

- annual grasses, such as barnyardgrass, large crabgrass, foxtail (giant, green, and yellow), and broadleaf signalgrass; and
- broadleaf weeds, such as ragweed, morningglory, and sesbania.

Methylated seed oil is the recommended spray additive at 1 to 2 pints per acre. Grazing restrictions are not listed on the label and are therefore discouraged.

Harvesting and Storage

Switchgrass used for bioenergy is harvested in one of two different cutting systems, called the one- and two-cut systems. The yield difference between a one-cut system and a two-cut system is minimal. In a one-cut system, switchgrass biomass is harvested following the first frost of the year, when conditions are favorable to be in the field. This system has several advantages. First, delaying harvest until after a frost allows individual switchgrass plants to translocate nutrients back into the soil, thus decreasing the amount of fertilizer required later. Secondly, harvesting this late in the season allows the stand to dry down to lower than 30 percent moisture, reducing the amount of time before baling and the excess weight of moisture hauled off the field. A two-cut system can be used if market demand is strong enough or if the producer is interested in using the first cut for hay production for livestock. However, this system requires fertilizer inputs between cuttings to remain productive. Some research suggests that multiple cuttings a season reduce stand longevity.

You can harvest switchgrass using traditional hay equipment. However, due to the volume of mature switchgrass and the length and diameter of the stems, a mower-conditioner is recommended. Conditioning hastens the drying process and crushes the stalks into a more malleable windrow, making it easier to bale. Switchgrass should not be cut lower than 6 inches. Cutting the stand too close to the ground can damage the plant's crowns, ultimately weakening the stand and reducing productivity. If you are using a one-cut system and grass moisture is below 30 percent, you can bale immediately after mowing and conditioning, requiring less time in the field. That can be helpful in late fall and early winter. Round balers can handle the amount of biomass potentially produced, but large, square balers are much more efficient and produce bales that are easier to transport and store. Switchgrass bales can be stored like traditional hay or straw bales. Ample time between harvest and storage is required to prevent spontaneous combustion. Bales should be stacked and covered whenever possible, preventing rot and decomposition before processing.

Fertility Management

Once a stand is fully established, fertilizer should be applied for stand maintenance and improved yields. For every ton of switchgrass hay removed, 22 pounds of nitrogen, 12 pounds of phosphate, and 58 pounds of potassium are removed (IPNI, 2014). Studies assessing nitrogen rates for switchgrass production suggest that between 50 to 100 pounds of nitrogen per acre should be added to maintain high biomass yields in a single cut system (Lemus et al., 2008). Phosphorous applications have shown not to influence biomass yields (Muir et al., 2001), but proper fertility management should be used to prevent future mineral mining and depletion. Potassium and phosphorous can be applied in their full amounts before spring green-up for a single-cut system. Split applications are recommended for two-cut systems. Nitrogen applied in amounts greater than 50 pounds per acre should be split into two applications: once at green-up, and another at 20 to 24 inches, before the stand is too tall to move equipment through and effectively apply fertilizer.

Pest and Disease Management

Currently, only a few significant diseases or pests have been identified that affect switchgrass production. These include rust, head smut, anthracnose, barley yellow dwarf virus, and panicum mosaic virus. The outbreak of these diseases can cause yield reductions up to 17 percent (Thomsen et al., 2008). Little research has been done on managing diseases because most of the documented cases have not been of economic importance. In terms of insects, few have been identified that cause damage to the switch-

grass plant. Grasshoppers are known to feed on it, but the extent of their damage has not been quantified. Other insects found in switchgrass include aphids, leafhoppers, blister beetles, chinch bugs, grasshoppers, stem borers, and wireworms. Since this is a native species that is still relatively wild in terms of domestication, variability exists within varieties to withstand insect or disease pressure. However, with increased production acreage and improved cultivars, it is not unreasonable to expect problems to develop over time (Garland, 2013).

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Publication 2874 (POD-07-18)

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