



SWITCHGRASS AS A BIOMASS FEEDSTOCK

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Production of Switchgrass (*Panicum virgatum*) as a biomass feedstock

Key messages

- Switchgrass is a fast-growing, perennial C4 grass native to North America. It grows in small dense clumps and can produce moderate to high biomass yields with low inputs, tolerating a wide range of conditions.
- Switchgrass is established from seed and has relatively low establishment and harvesting costs. Successful establishment requires attention to seed dormancy, weed management, planting depth, and timing.
- Switchgrass takes approximately 2-4 years to mature and can remain productive for 15-20 years depending on crop management, soil type, climate, and variety. There have been few switchgrass trials in the UK but yields of 4 to 14 tonnes per ha have been reported on experimental field sites.
- Switchgrass has several uses and benefits including control of soil erosion, forage for livestock, wildlife habitat and as a biomass feedstock.



Introduction

Switchgrass (*Panicum virgatum*) is a tall-growing perennial grass native to North America. It belongs to a clade of C4 grasses, which are among the most photosynthetically efficient species in the plant kingdom. Switchgrass comprises two major ecotypes that are adapted to either upland or lowland environments. Both ecotypes grow in small dense clumps and are capable of producing high biomass yields with low inputs. Switchgrass tolerates [a wide range of conditions](#)^[1] and can therefore be suitable for marginal or even [contaminated](#)^[2] land, although [yields on poorly productive, sandy soil, were low](#)^[3]. The upland ecotype has short fine stems and is more tolerant to cold environments. The lowland ecotypes have thicker and taller stems and grow in wet areas with mild winter temperatures. In the UK, lowland ecotypes are later flowering than upland types, allowing them to accumulate greater yields than lowland ecotypes, although they do usually mature fully before winter. As they mature earlier, the upland ecotypes have higher leaf loss with the associated translocation and leaching of nutrients, which promotes quality for combustion. Lowland ecotypes may be better suited to anaerobic digestion and ethanol production.

Switchgrass can exceed heights of 2 metres when mature, which may take 2–4 years in the UK. It can remain [productive for 15-20 years](#)^[4] depending on crop management, soil type, climate and variety.



Uses and benefits

- Switchgrass is a valuable soil protection cover. It is useful in [soil erosion control](#)^[5] and used in stream-side buffers. It has a dense canopy and an extensive network of deep roots which reduce raindrop impact, water runoff, and soil erosion.
- It is a good forage cover and habitat for a variety of [wildlife](#)^[6]. The canopy structure of switchgrass provides habitat for some birds, reptiles, amphibians, and mammals.
- The plant can provide [forage for cattle](#)^[7] and livestock bedding.
- It is used as an ornamental plant in gardens and landscaping.
- Switchgrass is a potential feedstock for multiple uses including combustion, anaerobic digestion, biodegradable plastics, the production of [ethanol](#)^[8] and butanol, and [packaging materials](#)^[9].
- Switchgrass has [carbon sequestration potential](#)^[10] and could reduce [atmospheric greenhouse gas emissions](#)^[11].

Establishment

Land management before planting in existing landscapes is important to scout for and control perennial weeds within the field to minimise stand failures in the establishment phase. [Weeds](#)^[12], if not effectively controlled during the establishment phase, can result in crop failure. Switchgrass is planted by seed at a recommended depth of 0.5-2cm and at seeding rates of [200-400 pure live seeds \(PLS\) per m²](#)^[12]. A seeding density of 5-15 kg/ha is recommended depending on the variety and soil conditions. Switchgrass requires a firm smooth seedbed and can be planted by both no-till and conventional tillage methods. Conventional seed drilling provides a more uniform stand development and seed depth.

Switchgrass displays a high level of [dormancy](#)^[13] which presents a challenge for germination. Breaking seed dormancy is important to reduce the risk of establishment failure and the costs associated with reseeding. [Studies](#)^[13] have reported various methods to break the seed dormancy of switchgrass including chemical, mechanical, thermal, and hormonal seed treatment. The seed dormancy of switchgrass is affected by the length of seed storage, storage conditions, quantity of seeds and soil conditions. It is recommended to conduct germination tests and [treat seed dormancy](#)^[14] by stratification (i.e., soaking seeds in water for about 1 month at 5-10°C then re-drying or by after-ripening (i.e., holding seeds at moderate, or preferably elevated, temperatures until the dormancy is broken)).

The ideal time to plant switchgrass is early spring after the last frosts (May to mid-June) when soils are moist, and the root system has plenty of time to establish. Switchgrass is a warm season grass and requires a soil temperature above 10oC for satisfactory germination.



Rolling is recommended both before and after sowing to conserve the moisture in the seedbed followed by application of a broadleaf herbicide to control weeds. Weed competition is a

major reason for switchgrass stand failure, especially during establishment. It is important to control weeds to avoid competition. Soil testing is recommended before planting to determine the recommended fertiliser application rates. Depending on the soil, nitrogen fertiliser application may not be necessary during the planting year as this will encourage weed growth and will increase the risk of switchgrass being outcompeted by weeds as well as increasing the establishment cost.

Site suitability

Switchgrass establishes best on well drained, fertile loam or sandy loam soils, but it can establish and persist under highly variable soil conditions. Switchgrass can be grown on marginal land not suitable for food and feed production and it will tolerate short periods of water-logging and, depending on the variety, has good tolerance of heat and drought stress. A [study^{\[15\]}](#) investigated different varieties of switchgrass for adaptation in Europe and found that the main factor determining the adaptation of varieties is the latitude of the origin of the variety.

Biomass production and harvesting

In an [experimental trial^{\[16\]}](#) in the UK, yields of as much as 8.8 to 14 dry tonnes per hectare have been reported, but these will depend on site, management, and [harvest time^{\[17\]}](#), and commercial plantations may have considerably lower yields. A different [study^{\[18\]}](#) in the UK of

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Switchgrass as a Biomass feedstock

a 2-4 year trial across four sites found lowland varieties (NL93/2) to have a yield potential of 9.6 tonnes per hectare annually, and upland varieties (Shelter and Cave-in-rock) to have yields of 7 tonnes per hectare annually. Switchgrass has shown mixed responses to the application of nitrogen: [in one trial^{\[19\]}](#), the Cave in Rock variety grown on poorly productive arable crop land increased by 43% in response to 100 kg/ha nitrogen fertiliser, but in a [different trial^{\[16\]}](#) only one variety out of seven, and only in one year, responded to 60 kg/ha nitrogen.

Mature switchgrass can be harvested once or twice per year with conventional haymaking equipment as the stem diameter and strength is similar to UK forage grasses. This is an important cost saving over coppice trees, which require specifically adapted forage harvesters. Harvesting usually commences from the second year after sowing. For combustion markets, harvesting can be conducted after frost when plants have senesced and translocated nitrogen and potassium back into the root system. Harvesting once per year will remove fewer nutrients from the soil, maximise biomass recovery and maintain stands. Harvesting twice per year for anaerobic digestion or ethanol markets will require more nitrogen and potassium applications to compensate for the nutrients removed in the first harvest. Harvesting more than twice a year adversely affects the long-term productivity and persistence of the crop. Switchgrass traits can be significantly affected by the [harvest timing^{\[17\]}](#).

Switchgrass is suitable for [thermochemical processes^{\[20\]}](#) such as combustion, gasification, and pyrolysis. A study found switchgrass composition of [lignin \(12.3%\), cellulose \(46.1%\), hemicellulose \(32.2%\), ash \(4.7%\)^{\[21\]}](#) to be suitable for thermochemical processes, hence it is an attractive feedstock for bio-based products.

Feedstock	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Ash (%)
Miscanthus	41.9	26.6	13.3	3.2
Switchgrass	46.1	32.2	12.3	4.7
Wheat straw	34.9	22.5	21.3	9.4
Rice straw	41.6	31.5	12.5	14.4
Corn stover	39.4	33.1	14.9	
Sorghum	15.0	12.3	5.8	0.4
Sugar cane	48.6	31.1	19.1	1.2
Hardwood (beech)	43.3	31.8	24.4	0.5
Softwood	40.4	31.1	28.0	0.5

Source: Adapted from [Pauly and Keegstra \(2008\)^{\[21\]}](#)

Pests and diseases

Switchgrass disease levels are relatively low and not considered a cause for concern. Fungal diseases such as rust, leaf spot and smut have been reported to affect switchgrass in North America. Varieties developed in dry areas will be more susceptible to [fungal disease](#)^[14] when grown in humid conditions. The lowland ecotypes are known to be more resistant to rust. In North America, aphid, leaf miner, double lobed moths and fruit flies occasionally attack switchgrass causing reduction in yield. Damage from rabbits, leatherjackets and slugs can occur during the first year of establishment.

Economics

Switchgrass is established from seed and so has a relatively [low establishment cost](#)^[22] compared to rhizome or plug planted Miscanthus and other biomass crops like willow and poplar, with input costs around [£357/ha](#)^[23]. Where production costs have been considered, [research](#)^[24] indicates that switchgrass in some European countries, including UK, could attract values from 130 to 250 £/ha/year. In addition, harvesting costs are much reduced when compared to the aforementioned biomass crops as readily available farm machinery is used rather than specialist machines usually in the hands of contractors. This makes it a practical option among biomass crops. There is little data available on the commercial production of switchgrass in the UK. Most existing plantings are for research purposes.

Endnotes/Hyperlinks

- 1: <https://www.sciencedirect.com/science/article/pii/S0167880916304923>
- 2: <https://www.nature.com/articles/s41598-019-56655-w>
- 3: <https://doi.org/10.1016/j.biombioe.2012.03.017>
- 4: <https://envirocrops.com/resource/switchgrass-best-practice-guidelines>
- 5: <https://onlinelibrary.wiley.com/doi/full/10.1111/gcbb.12749>
- 6: <https://www.sciencedirect.com/science/article/pii/S0006320701001264>
- 7: <https://access.onlinelibrary.wiley.com/doi/full/10.2134/cftm2017.08.0053>
- 8: <https://www.sciencedirect.com/science/article/pii/S1364032122000442>
- 9: <https://www.sciencedirect.com/science/article/pii/S0926669022001443>
- 10: <https://www.sciencedirect.com/science/article/pii/S0961953497100745>
- 11: <https://www.mdpi.com/2075-1729/12/12/2105>
- 12: <https://onlinelibrary.wiley.com/doi/epdf/10.1002/bbb.106>
- 13: <https://www.sciencedirect.com/science/article/pii/S0961953415001737>
- 14: <https://www.tandfonline.com/doi/full/10.1080/07352680500316433>
- 15: https://www.researchgate.net/publication/229013519_Switchgrass_variety_choice_in_Europe
- 16: [https://doi.org/10.1016/S0960-8524\(01\)00201-2](https://doi.org/10.1016/S0960-8524(01)00201-2)
- 17: <https://access.onlinelibrary.wiley.com/doi/full/10.2135/cropsci2012.10.0568>
- 18: <https://www.sciencedirect.com/science/article/pii/S096195341200044X>
- 19: <https://doi.org/10.1016/j.biombioe.2012.01.034>
- 20: <https://www.sciencedirect.com/science/article/pii/S0360128511000414#bib17>
- 21: <https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-313X.2008.03463.x>
- 22: <https://www.sciencedirect.com/science/article/pii/S136403210800138X>
- 23: <https://www.crops4energy.co.uk/switchgrass/>
- 24: <https://www.mdpi.com/1996-1073/13/5/1222>

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