



Switchgrass Production in Ontario: A Management Guide

Samson, R., 2007. *Resource Efficient Agricultural Production (REAP) - Canada*

Revised from: Girouard., P., B. Mehdi, R. Samson and P. Blais, 1999. Joint publication by Resource Efficient Agricultural Production (REAP) – Canada and the Research and Technology Transfer Section of the Collège d'Alfred of the University of Guelph.

Introduction

New levels of concern about the need to reduce greenhouse gases and develop low cost renewable fuels are of increasing interest in biofuel production systems. Since the 1980's switchgrass, a native C4 or warm-season grass has been identified as a promising bioenergy feedstock through studies by the US department of Energy. It has been under investigation in Canada as a bioenergy crop since 1991. Several market opportunities involving switchgrass are now emerging for growers in Eastern Canada. This management guide intends to provide the basic knowledge on how to successfully grow switchgrass.



A long history of use

Switchgrass (*Panicum virgatum* L.) is a native, perennial warm-season grass. Along with big bluestem and indiangrass, it is one of the three dominant native grasses found in the North American tallgrass prairie prior to settlement. In Ontario, it can still be found in remnant oak savannah prairies. Switchgrass has been researched since the 1940's in the United States as a mid-summer forage crop. It is most commonly used for livestock forage in the south-central states. In the 1990's it was widely used in the Conservation Reserve Program (CRP) in the United States. To enhance its erosion control and biodiversity value, it is now recommended in the latest Conservation Reserve Enhancement Program (CREP) in the United States to be used in mixtures with other warm-season grasses.

Warm-season agricultural crops including corn, sorghum, millet and sugarcane are widely grown in the world. They are commonly grown in regions experiencing warm temperatures during the growing season. In Ontario, switchgrass produces most of its biomass in the warm summer months of June through August. The successful production of switchgrass requires

different production techniques and harvest schedules than those used for cool-season grasses such as timothy and brome grass. In particular, switchgrass can be relatively slow to establish. A switchgrass stand that appears poor in the seedling year often produces a high yielding stand in subsequent years. Adapted warm-season grasses have few pest and disease problems and are rather remarkable for their stand longevity and stable productivity year after year.

Varieties of Switchgrass

Switchgrass varieties are classified into two broad categories: lowland and upland. Lowland ecotypes historically developed under floodplain conditions, while upland ecotypes developed under drier upland sites. Yields of up to 25 tonnes per hectare (10 tonnes/acre) have been achieved with some lowland varieties in research trials in the southern United States. Unfortunately, lowland varieties are more susceptible to winterkill. In most areas of Ontario, upland varieties will provide Ontario farmers with the best productivity and stand longevity. In Southwestern Ontario, some northern lowland ecotypes may prove to be adequately hardy and included in mixed warm-season grass seedings in the future.

Cave-in-Rock is the most widely planted variety for northeastern North America. In more northerly areas of Ontario (i.e. less than 2500 corn heat units or CHU) other early maturing varieties such as forestburg, sunburst, and shelter may prove more reliable in terms of winter hardiness and productivity. Ontario farmers should preferentially choose varieties originating from the eastern United States as these tend to be more disease resistant. Some western originating switchgrass varieties have developed leaf diseases in Ontario. New switchgrass varieties with improved seedling vigor, disease resistance and yield are currently under development.

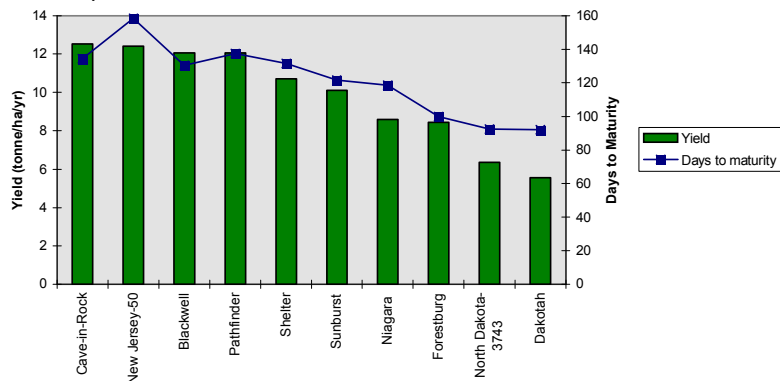


Figure 1 – Yield (oven dry tonnes ha⁻¹) of switchgrass cultivars at Ste. Anne de Bellevue, Quebec (1993-1996)

Seed

Eight to 10 kilograms of Pure Live Seed (PLS) per hectare are recommended for a successful establishment. Switchgrass is usually sold based on its PLS content as the seed varies greatly

in purity and germination. Seed lots with equal amounts of PLS may differ in their volume of bulk seed. This must be taken into consideration when calibrating seeding equipment.



Newly harvested switchgrass seed can have a high percent dormancy. High dormancy seedlots will require higher seeding rates (or storage to provide acceptable germination levels) for successful field establishment. For newly harvested seed, a dormancy rating of 10 percent or less is excellent. Seed cost currently varies between \$7-\$21/kg, depending on the desired variety and demand. In Ontario, big bluestem can be included in mixtures with switchgrass to enhance environmental benefits and to reduce potential for disease pressure on monoculture seedings of switchgrass. New releases of big bluestem appear to have similar productivity levels as switchgrass and as such an overall seeding rate of 8-10 kg /ha of PLS can be used for switchgrass and bigbluestem seedings. It is best to use a seeding rate of 4 kg/ha switchgrass and 6 kg/ha big bluestem if a mixed planting is desired. Big bluestem requires better field drainage than switchgrass. Big bluestem that has had the seed coat buffed during seed cleaning to remove fine hairs is highly preferred. The advantage of buffing is that the big bluestem seed can flow through the bromegrass seed box on forage seed drills. Switchgrass and big bluestem seed is available from a number of Canadian and U.S. dealers.

Establishment

Experience in Ontario indicates that switchgrass is easier and faster to establish on loam and sandy soils than on clay soils. The roots and crowns of switchgrass spread more readily on these lighter soil types. This results in a maximum yield level being achieved in a shorter time period. Typically switchgrass produces about 30% of its biomass potential in the first year, 70% in the second year and 100% of maximum biomass production by year 3. Switchgrass seed is fairly small, therefore poor contact with the seedbed caused by clay clumps will result in poor or uneven germination. Clay soils are also usually slower to warm up in the spring. Packing fields before and after planting is highly recommended on all soil types, especially on clay soils. A good rule of thumb for seeding is that a footprint should barely be visible in the soil before seeding.

Switchgrass will establish best on well-drained soils (surface and/or tile drainage) that warm up early. On sandy loam soils in corn growing areas, switchgrass is highly competitive with invading perennial weeds. Increased competition from aggressive cool-season perennial grasses (such as quackgrass, bromegrass and reed canary grass) in establishing stands of switchgrass can be expected at more northerly sites, in heavier soils and fields formerly in cool-season grass production. Due to the extensive perennial root system and drought tolerance, switchgrass is relatively productive on medium to lower fertility soils compared to most annual field crops. Switchgrass is well suited to be grown in areas with less than 2600 CHU which are marginal for corn

and soybean production. Soil pH should be above 6.0 for optimal yields.

As switchgrass is fairly slow to form a canopy, weed control is critical to achieving a successful establishment. In the fall preceding establishment, fields can be sprayed with a broad-spectrum herbicide to eliminate problem perennial weeds, such as quackgrass, from invading the establishing stand. Summer or fall tillage is recommended for forage and pasture fields in order to break sod clumps. Use of spring applied formulations of "Round-up ultra or max" should be avoided as growers have reported phytotoxic effects on switchgrass establishment.

In the spring, seeding should be performed when soils are relatively warm, usually between May 15th and June 10th. Soil preparation should include one or two passes of harrow (or disk) and packing (cultipacking). Seeding in conventionally tilled fields is best performed with a Brillion seeder at a seeding depth of 0.5 -1.0 cm (1/4 to 1/2 inch). If use of a mixture is planned, buffed big bluestem seed can be seeded using the bromegrass seed box on Brillion seeders. If the field is not fine and firm after planting, it should be packed again immediately. No-till soybean seed drills are commonly used for no-till seeding of switchgrass in all areas of the United States. The alfalfa box on these drills is used for the switchgrass.

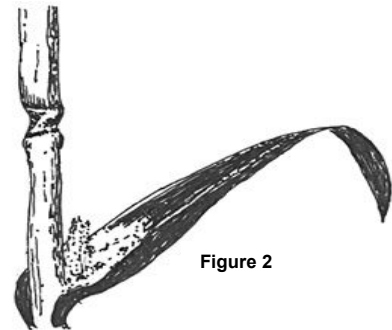


Figure 2

Switchgrass seedlings can be difficult to distinguish from annual grass weeds. A key feature of switchgrass plants is the white patch of straight hair at the point where the leaf (topside) attaches to the stem (Figure 2). Another means of identifying switchgrass during its first 6 weeks of growth is that the stems have a reddish-purplish tint and are round. Switchgrass may take weeks to emerge depending on the season. The switchgrass seedlings are frequently smaller than early emerging annual grass weeds. A stand is successfully established if 10-32 seedlings per m² (1-3 seedlings per ft²) can be found at the end of the establishment year. Some winter heaving problems can be experienced in the seeding year. Heaving can arise especially on clay soils and on fields where plants are relatively small (less than 20cm) and weakly rooted into the soil going into the winter.

Establishment: Weed Control

Switchgrass establishes best on fields that have modest annual and perennial grass pressure. Spring cultivations at 7-10 day intervals prior to seeding can help reduce annual weed pressure in fields. No herbicides are registered for use on switchgrass in Canada. Weed control research has mainly been conducted on upland ecotypes of switchgrass. Studies are available from a number of institutions in the United States and from the University of Guelph in Ontario. It is the farmer's responsibility to read and comply with the label instructions of each product. Switchgrass seedlings and mature plants show tolerance to atrazine. Guidelines from the United States are to use Aatrex atrazine at 1.1-2.2 kg/ha of active ingredient (1-2 lbs./acre) at, or soon after, planting. Basagran[®] (bentazon) and Laddock[®] (blend of atrazine and bentazon) are effective against most post-emergent broadleaf weeds, with minimal crop damage. Switchgrass should not be sown as an underseeding in cereal crops as it is not shade tolerant.

Grass weeds such as barnyard grass, foxtail and crab grass are the most difficult to control in switchgrass stands. It is difficult to find herbicides that effectively remove grass weeds from switchgrass seedlings without causing injury to the switchgrass. Research is ongoing on this issue and guidelines should be available within the next few years. In the event of weed escapes, the field can be clipped just above the switchgrass canopy up to two times during the summer months. Cutting off the growing point of the switchgrass will significantly retard switchgrass development. Loss of stands or delayed establishment due to weed competition is more likely to occur with seedlings on heavier soils. If big bluestem is used in mixed seedlings with switchgrass, no more than 1.1 kg/ha of active ingredient of atrazine should be applied to the field. In the U.S., Plateau® (imazapic) herbicide is used on pure big bluestem seedlings at a rate of 0.07a.i./ha to control annual grass weeds. Plateau® is not suitable for use on switchgrass and will cause significant injury during establishment. Organic farmers looking to grow switchgrass should use a combination of cultural weed control measures. They should also consider planting in sandy-loam fields that have low residual nitrogen fertility (example following a fall rye crop in the rotation) and that are known to be relatively free of perennial weeds.



Establishment: Fertilization

In almost all cases, nitrogen fertilization is not utilized in the establishment year. Switchgrass is an excellent nutrient scavenger in establishing fields. Applying nitrogen fertilizer commonly stimulates weed growth and this reduces the competitive ability of switchgrass. Potassium and phosphorus fertilizers are not applied during establishment, unless levels are low (less than 81 ppm for potassium, and less than 10 ppm for phosphorus, according to OMAFRA guidelines for forage crops). Switchgrass seldom responds to potassium and phosphorus fertilizer as it has a large root system and relies on mycorrhizae for phosphorus uptake. It is best to avoid manuring fields before planting to minimize weed competition.

Establishment: Harvest

Fall dormancy of the switchgrass is generally delayed in the seeding year and this increases risks of winter hardiness problems in the first winter. To ensure good winter hardiness and vigorous regrowth, it is recommended that switchgrass grown in the establishment year be overwintered prior to harvest.

Production Years

Research conducted in eastern Canada indicates that maximum production is first attained during the third growing season. Once established and properly maintained, a switchgrass stand will remain productive for an indefinite period. Experience has shown in Ontario that if switchgrass stands are subject to winter injury or heaving, they can commonly recover in the subsequent growing season. Switchgrass has large underground carbohydrate reserves which help regenerate regrowth.

Production Years: Harvesting

As a biomass crop, switchgrass is best grown as a one-cut per year crop, with the harvest performed any time after fall dormancy is well initiated (i.e. leaf yellowing). This ensures adequate nutrient and carbohydrate translocation to the root reserves to help encourage winter survival. The harvest period can include late fall, mid winter (in snow-free conditions) and early spring (anytime between mid-April and late-May). If fall cutting switchgrass, leaving at least a 10 cm stubble to improve winter survival and reduce winter heaving. The base of the stem of switchgrass is the slowest part of the plant to dry out in the fall. It may not be possible to fall-harvest switchgrass when wet fall harvest conditions occur. Early maturing varieties can be chosen to help create an earlier fall dry-down of the crop. As well, varieties that have minimal lodging and thin stems tend to dry down more effectively. Another common problem on heavier soils is that field conditions are too wet in the fall to enable baling and transport equipment for fall harvesting. Delaying the harvest to the following spring has the advantage of improving winter survival and weed control. It also reduces nutrient extraction resulting in reduced fertilizer requirements and improves combustion properties of the material. The ash content of switchgrass typically declines from 5% in the fall to 3% in spring. By spring the crop is typically harvested at 12-14% moisture as good drying conditions are present. This can eliminate the need for drying the fibre prior to pelleting. Some drying can also be expected when bales are placed in covered storage. Commonly fall stored baled forage at 16-17% moisture will be at 12-14% moisture content by spring.

The main problem that has been identified with overwintering switchgrass in fields has been breakage of the seed heads and leaves by the winter winds and ice storms. Typically 20-30% of the total dry matter can be lost in fields. As well, cutting the material in the spring can lead to large harvest losses due to material shattering because of its dry and brittle state at harvest. Swathing standing switchgrass in the spring can substantially reduce harvest losses compared to harvesting with a mower conditioner. Another possible harvest option is to fall mow and spring harvest the material. This approach may reduce winter breakage and promote more rapid soil warming and field drying in the spring. This harvest system appears promising based on preliminary field trials. Well-drained sandy soils offer the greatest flexibility for farmers in accessing fields under wet weather conditions.



Production Years: Fertilization

In most cases, the only operation required following harvesting is the application of nitrogen fertilizer. For a late fall or spring harvest regime, 50-60 kg of actual nitrogen per hectare every year (45-53 lbs./acre) is sufficient to sustain production. Over-fertilization with nitrogen usually results in crop lodging, which ultimately results in yield reduction and harvesting difficulties.

By adopting a late winter or spring harvesting regime, phosphorus and potassium fertilization requirements are minimized. Usually no phosphorus or potassium is applied on medium to rich soils under switchgrass cultivation. Soil concentrations of these two nutrients should be monitored 2-3 years after establishment and fertilization performed if deemed necessary. Modest rates of solid and liquid manure and sewage sludge can be applied to established switchgrass stands when actively regrowing (typically in early June).

Biomass and Energy Yields

Once fully established in Ontario, switchgrass can typically produce 8-12 tonnes/ha of harvestable dry matter by fall. Leaving the crop in the field over winter will cause some reduction in harvestable yields. However, the resulting material will have an improved quality for combustion applications. Research is ongoing to optimize the yield and quality of switchgrass through both variety improvement and harvest management. Typically switchgrass and grain corn have similar energy contents on a dry matter basis of approximately 18.5 GJ/tonne. Assuming a harvested grain corn yield of 6.5 tonne/ha and switchgrass yield of 10 tonne/ha, switchgrass produces 185 GJ/ha of energy vs 120 GJ/ha for grain corn. If the fossil energy inputs used for crop production are subtracted from energy output, the net energy gain per ha is 73% higher for switchgrass than grain corn.

Costs of Production

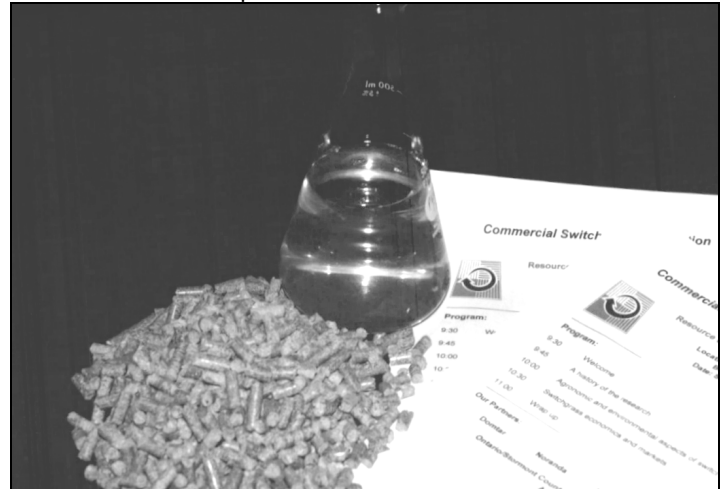
Switchgrass represents the lowest cost means to capture and store solar radiation in a field crop in Ontario. The main factors contributing to making it a low cost energy producing system are: its perennial nature and stand longevity, its adaptation to marginal farmlands (i.e. low land rents), its low input requirements and its moderate to high productivity on marginal soils. Variable costs to grow and harvest switchgrass are approximately \$40-\$50/tonne.

The cost of harvesting and transporting the crop to a conversion plant is approximately \$30-\$35/tonne. Any efficiency gains made in these two areas will strongly influence returns to farmers. A major advantage of developing local conversion plants to produce fuel pellets are that they can help reduce hauling distances and enable bulk switchgrass harvesting and delivery to conversion facilities. Other costs include the annual fertilization charges (i.e. 130 kg/ha of 46-0-0 at \$500/tonne) of approximately \$75/ha, and the amortization, usually over 10 years, of the establishment costs incurred in the first year. Land rent can have a strong influence on overall switchgrass production costs. A land rent of \$250/ha adds an additional \$25/tonne to production costs, if a 10 tonne per ha yield is obtained.

Markets

Switchgrass can be used in a diversity of agricultural and energy markets. It can be used for livestock bedding, as part of a dry cow ration, as a mushroom compost substrate, as a horticultural or roadside mulch and in straw bale house construction. In Ontario, the main emerging bioenergy application is as a pelletized fuel for commercial heating. On-farm applications can include greenhouse heating, heating of livestock buildings, and corn drying. Switchgrass can also be used as a fresh or ensiled feedstock for biogas production. The main interest presently in Ontario is its use as a commercial fuel pellet. Preliminary combustion trials with switchgrass have been conducted in both residential pellet stoves and commercial boilers. Fall harvested switchgrass appears to have more difficulty in combustion applications when it is used as the only fuel. Overwintered switchgrass appears to have few limitations for use in combustion systems designed for higher ash fuels. Experience has also shown that overwintered switchgrass has superior pellet durability when compared with fall harvested switchgrass.

Pelletizing switchgrass typically costs \$35-\$50/tonne. If the crop can be grown for \$70/tonne and pelletized for \$40/tonne it could be a highly competitive fuel source to compete with rising propane and natural gas costs. At a bulk retail price of \$125/tonne, switchgrass pellets cost \$7/GJ on an energy basis. Ethanol currently receives a federal incentive of 10 cents per litre or \$4.48/GJ. If federal and provincial incentives are also applied to switchgrass it will become a highly competitive energy source in Ontario that will help revitalize the farm sector.



Switchgrass and Climate Change

Switchgrass and other warm-season grasses could provide a major solution in helping Canada achieve major emission reduction targets. Overall, switchgrass pellets can reduce greenhouse gas emissions by about 90% when compared with using an equivalent amount of energy in the form of fossil fuels.

Switchgrass can also reduce greenhouse gas emissions by increasing the carbon stored in landscapes through increased carbon storage in roots and soil organic matter. It has been found that land conversion to switchgrass on CRP plantings in the United States has led to 40 tonnes/ha of CO₂ being stored compared to conventional land use.

Additional Information

An electronic version of this switchgrass production guide and additional reports are available at www.reap-canada.com

Resource Efficient Agricultural Production (REAP) - Canada



Box 125, Centennial Center CCB-13
Ste. Anne de Bellevue, QC, H9X 3V9
Tel: (514) 398-7743; Fax: (514)-398-7972
E-mail: info@reap-canada.co
Web: www.reap-canada.com

Acknowledgements

This management guide was made possible with support from the Ontario CanAdapt program and the OMAFRA Alternative Renewable Fuels Fund.