A MANAGEMENT GUIDE FOR PLANTING AND PRODUCTION OF SWITCHGRASS AS A BIOMASS CROP IN EUROPE

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ABSTRACT: Switchgrass is a perennial C4 grass native to North America, where it occurs naturally from 55º N latitude to deep into Mexico. It is used for soil conservation, forage production, as an ornamental grass and more recently as a biomass crop for ethanol, fibre, electricity and heat production. As biomass increases in importance in Europe it is expected that switchgrass can play an important role in supplying sustainably produced lignocellulosic biomass. One of the main attractive features being low establishment costs and high productivity under low input conditions. Recent European research has led to sufficient results to merit publication of a management guide. In this guide all aspects necessary to produce switchgrass from variety choice, site selection, establishment, nutritional requirements, pest management, economics, harvest options, to application for energy or fibre are discussed. For details we refer to the enclosed pages. These guidelines are based on available literature and three-year Europe wide small plot experiments. Therefore the guidelines should be seen as preliminary. Improved guidelines should become available as large-scale experiments are conducted in Europe. See www.switchgrass.nl
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1 INTRODUCTION

Switchgrass (*Panicum Virgatum* L.) is a warm season perennial herbaceous grass that is established from seed. It develops rhizomes and is also deep rooting, often more than 2 m. It grows 50-250cm tall depending on the variety and climatic conditions. It has the C4 photosynthetic pathway and is an efficient user of nitrogen and water. This makes it potentially a very productive grass. Productivity will vary between 6 tonnes dry matter (DM)at low fertile Northern European sites up to 25 tonnes at fertile Southern European sites. If properly managed it has long-term productivity potential (> 15 years) with a high level of sustainability.

Switchgrass is indigenous to North America and is found from Mexico into Canada but it does not occur naturally above the 55 0 N latitude. There are two main types: lowland types that are found on wetter sites such as flood plains. They have tall, thick, coarse stems and bunch growth habit. The upland type is adapted to drier habitats. It has thinner stems than the lowland type and stem number is greater. Some have a turf -like growth habit.

Switchgrass is best compared to *Miscanthus*, another C4 biomass grass. Compared to *Miscanthus* (gigantheus), switchgrass is smaller, thinner and generally leafier. As it is established from seed, establishment is less expensive and involves less risk than *Miscanthus*, which is propagated by rhizomes, which is more expensive. There are indications that switchgrass is more drought tolerant and may do better under low fertility (low input)

2 APPLICATIONS

In the USA switchgrass is used for erosion control and to provide forage under hot and dry conditions. In recent years switchgrass has been intensively studied in North America and more recently in Europe as a potential biomass crop for power production through direct combustion and possibly for lignocellulosic ethanol production. Other uses of switchgrass include fibre production, and wildlife habitat improvement.

3 GROWTH CYCLE

Shoots emerge in spring when soil temperature rise above 10 C. Growth can be very rapid with up to 75% of biomass being formed by mid-summer when flowering occurs. After flowering is complete, stems become lignified and start to senesce, as the plant becomes dormant. In southern European countries the growth cycle may be complete by late summer. During senescence minerals are relocated from leaves and stems to roots and rhizomes where it is stored for the next growth cycle. This natural process improves the quality of the biomass for combustion.

4 SITE SELECTION

Deep soil that has good water holding capacity and adequate drainage is best but switchgrass is adapted to a wide range of soils. Shallow soils, stony soils and occasionally waterlogged soils are also suitable. When grown under low soil fertility and pH (acidity) it will have relatively high yields compared to temperate grass species or energy tree crops like willow coppice

5 PREVIOUS CROP

Spring and summer germinating weeds, especially perennial weeds and volunteers can be a serious threat to switchgrass establishment. Sites with severe weed problems should be avoided but if this is not possible weeds should be treated well in advance of planting. To reduce the risk from weeds it is important to plan ahead.

Start your weed elimination strategy in the year before planting. Control of perennial weeds will be better because any re-growth can be dealt with before the switchgrass is sown. Take into account any specific requirements resulting from the previous crop for example, avoid leaving surface residues because it can interfere with sowing and prevent good seed to soil contact.

6 SITE CONDITIONS

Switchgrass is slow to establish and it is important to follow basic guidelines that have proved successful in North America and Europe. Eliminate perennial weeds in particular since these are the most difficult to control after the crop has been planted (see previous crop). Prior to cultivation, compacted areas should be sub-soiled. After ploughing, use any secondary cultivation necessary to produce a firm fine seedbed. It has been shown both in the USA and recently in Europe that no-till drilling is also possible.

7 SOIL FERTILITY

Switchgrass is well adapted to low fertility and acid soil conditions. It has a large and deep root system that is very efficient in scavenging nutrients. It utilises mycorrhizae in taking up phosphorus.

Under ideal conditions one should aim for a neutral pH status at planting. In the first year no nitrogen should be applied because it is not necessary for the development of the crop and can promote weed growth leading to competition with seedlings and possibly smothering them. Phosphorus and potassium should be applied if soil availability is low. In later years application of nutrients should be at a level that anticipates rising productivity and also takes into account losses of minerals in harvested biomass. Normally stems are harvested when they are dead, the mineral content is low, and fertiliser application to compensate for this loss may only be required every few years. Nitrogen requirement is low and some studies show that soil reserves, N re-mobilised from roots and atmospheric deposition may be adequate in NW European conditions. On soils of low fertility or where irrigation is applied additional N may be required. The first European studies show that between 0 to 50 kg N/ha/year is adequate for NW European sites while at higher productive sites in southern Europe 50 to 100 kg N/ha/year should be adequate. More specific recommendations for quantity of nutrients cannot be made because it will depend on the fertility status of the site, however phosphorus and potassium levels can be kept low. High N applications may contribute to lodging. Lodging has been observed at several experimental sites in NW Europe and can reduce yield and increase moisture content of the biomass.

8 VARIETY CHOISE

A number of varieties are available from North America that have been found to be adapted to European conditions. Variety choice will be governed by the latitude of the site on which planting is intended. Varieties originating from Southern American areas will do best in Southern locations in Europe however they still are productive in Northern Europe but over-winter survival may not be as good as varieties of northern origin. Results from the European switchgrass network show that varieties can be grown further north in Europe than on the American continent probably because maritime influences moderate the climatic conditions.

A wide range of varieties has been tested under European conditions and many have proven to be well adapted. The following varieties have both given good results at their area of adaptation in Europe and are commercially available (in the USA):
Variety Cave-in-Rock is adapted to NW European areas (UK, NL, D).

Variety Kanlow is adapted to more southern areas (Southern UK and D, Northern IT). The variety can experience winter survival problems at more northern latitudes especially in the first year.

Variety Alamo is best suited to Southern regions of Europe (GR, IT). It may not survive winter in Northern Europe, especially in the first year, and quality will be low.

9 PLANTING

Seed can be sown in a conventional manner with a drill or direct-drilled (no-till) or broadcast. Whatever method is used, rolling before and after sowing is often desirable, particularly when seed is broadcast to ensure good seed to soil contact but don't roll if the soil is wet because surface compaction or crusting might result. Sowing depth should be about 10mm seed sown deeper than this may fail to establish. Seed sown into a loose seedbed may lodge later.

10 TIMING OF PLANTING

Sow switchgrass when the surface soil is warm. Best results will come from soil temperatures above 10C and when there is some moisture in the seedbed but not when it is too wet. Avoid dry seedbeds, because it can result in poor germination and establishment. In northern Europe sowing would normally take place in late April or May. A good guide to the conditions required for planting switchgrass is that they about the same as that for planting *maize Zea mays*). When switchgrass is sown too early the seedlings will not be able to compete with the weeds due to the relatively high temperature requirement for the grass.

11 SEED RATE

Seed rate is based on the number of live seeds and germination rate (pure live seeds). Germination rate can vary widely with switchgrass depending on the age of the seed. Freshly harvested seed has a high dormancy and often seed is stored for a year before it is used. Germination can be improved by stratifying seeds. Before seed is purchased it will have been germination tested and the percentage of pure live seed calculated, from the information the seed rate is calculated. Still, storage may change seed dormancy and it is

recommended that a simple germination test be performed to check seed germination rate. Very little information is available on optimum seeding rates in Europe. The best estimate is that a seeding rate of 400 PLS per m^2 should be adequate in NW Europe and 200 PLS per m^2 southern Europe. This means that the seed rate will be between 10 kg and 20 kg /ha.

12 DRILLING EQUIPMENT

Switchgrass seeds are small, and have a hard polished skin. There are about 500-1000 seeds/g depending on the variety. If a cereal drill is used, it may require a small seeds roll to be fitted. The seed drill must be capable of sowing the seed evenly along the row. Row width should be around 15cm.

13 WEED CONTROL

Growth is slow in the first year and seedlings compete badly with weeds. Keep in mind that weeds only have to be managed so that enough switchgrass seedlings survive the first winter and re-grow in spring. When this can be achieved generally no further weed control is necessary in following years as switchgrass will out-compete weeds when temperatures increase in spring.

Good and timely seedbed preparation, possibly preceded by a false seedbed, is necessary.

To increase the chances of adequate establishment and re-growth after the first winter, herbicides can be used. Keeping in mind that at the moment, to our knowledge, no herbicides have been specifically been registered for switchgrass. Glyphosate can be applied before seedbed preparation. Atrazine can be safely used pre or post emergence. To check broadleaf weeds ioxynil, bromoxynil, mecoprop, bentazone, and CMPP have been used on switchgrass.

Some of the herbicides can cause scorching and check growth. Use all herbicides at low dose rates and apply more if necessary. The most important mechanical weed control measure is mowing of weeds just above switchgrass height, when necessary. It is important not to cut the leaves switchgrass seedlings because this can seriously jeopardise the ability of the plant to survive the winter.

14 PEST AND DISEASE CONTROL

Diseases have not been a problem in switchgrass in Europe but crops still require regular inspection. No serious problems from pests have been reported. If there is a problem from rabbits, field margins should be fenced.

15 YIELD DEVELOPMENT

Depending on the soil type optimal productivity is reached in 2-3 (on light soils) to 4-5 years (on heavy soils. Yield in the first year is low and it at northern latitudes may not be economic to harvest. In the second year yields can be 8-10 t dm/ha and increase further in the third year. Early frosts or droughty conditions may delay the development of full yield potential.

16 MANAGEMENT OF ESTABLISHED CROP

Established switchgrass can compete effectively with weeds when temperatures rise in spring. Lodging can be a problem.

17 HARVEST

When switchgrass is grown for biomass (energy, fibre, etc) delayed harvest in winter/early spring is recommended. Harvesting the crop before senescence (in fall) will lead to lower winter survival and reduced spring re-growth and possibly leading to stand loss. The harvest is executed using normal grass baling methods and equipment. If the crop is to be stored for a longer period the moisture content should not be above 15-20%. The rate of dry-down and the moment of re-growth determine the harvest window in winter/early spring. If the crop is not lodged, the crop has had time to senesce and the stems are thin enough, adequate moisture content reduction will be reached before re-growth in spring.

18 PRODUCTION COST

Preliminary estimates of the production cost (without land cost) of switchgrass vary between 24 Euro per tonne DW in Greece and 62 Euro per tonne DW for the Netherlands. The costs should compare favourably to *Miscanthus* since the cost and associated risk of establishment is lower.

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For further information see: www.switchgrass.nl