Envirocrops

Best Practice Guidelines

Reed Canary Grass

May 2024

Contents

1. Introduction

1.1 Reed Canary Grass

Reed canary grass (*Phalaris arundinacea L.*) is a perennial grass which is naturally distributed throughout Europe and in temperate regions of Asia and North America. The grass is tall and leafy and in natural conditions is most commonly found growing along water margins.

Reed canary grass (RCG) grows rapidly under northern European conditions and is recognised as a crop with multiple uses; the principal market being heat and electricity production (a 'biomass crop'). These guidelines, therefore, are written with the expectation the crop is being grown for the energy market. However, reference is made to other uses.

Reed Canary Grass (RCG)

As a bioenergy crop, RCG occupies its own niche and offers an alternative to other bioenergy crops such as Miscanthus and Short Rotation Coppice willow. RCG biomass yields on mineral soils are unlikely to be as high as other biomass crops, but the cheap cost of establishment means that production costs are typically quite low. It is, however, easy to establish compared to other bioenergy crops and grows well on poor, wet soils on which other crops can struggle. Additionally, its earlier harvesting interval enables a greater year-around spread in biomass supply.

Environmental concerns including climate change, along with a global desire to source alternative energy supplies, have led to interest in the cultivation of bioenergy crops. Perennial herbaceous grasses can play an important role in this and can contribute a number of desirable attributes to cropping systems including:

- Reducing soil erosion between rivers and streams in arable fields
- Improving water quality by filtration
- Creating an ideal nesting habitat and shelter for wildlife, including birds and small, ground-dwelling mammals
- Absorbing carbon dioxide, and air-borne/soil-borne pollutants
- Having lower agricultural chemical and nutrient requirements, and,
- Increasing the organic matter content of the soil.

In Year 1, RCG can also be used for feeding livestock (but not grazing). From Year 2, in the early season, the green shoots can be used to feed livestock, by grazing (or made into silage). If left until winter/spring (when the crop is brown and dry) it can be used as bedding (instead of straw). Other uses remain undiscovered as yet.

RCG is easier to establish than other bioenergy crops although good seedbed preparation and timely weed control is still necessary during the establishment phase. It takes one to two years to establish and reach full yield potential, and the crop can then remain productive for up to ten years after which its productivity declines. Once established, it can produce five to six tonnes of dry matter/hectare.

RCG does not need to be harvested every year. Depending on the planned objectives of the grower these could include soil improvement, a zero nutrient input and/or a low-cost system. From a starting position of poor soil, the less it is harvested during a 10-year period, the higher the chance of restoring that soil to a high output cereal or livestock system once the crop is finally destroyed and incorporated. This is true soil ‘regeneration’ which can also be financed by available public/private schemes during that period.

1.2 Growth cycle

RCG can be grown from seed. It spreads by thick underground stems called rhizomes, which are approximately 1 cm thick, and can root to as deep as 3 m. Once mature it reaches a height of 150-200 cm.

Reed Canary Grass (RCG) seeds. Photo courtesy of Cotswold Seeds[1]

Once established, growth and productivity peak twice during the growing season, first in late spring and again in late summer. These growth peaks are under separate genetic control, with leaf and inflorescence growth dominating in the spring and stem and rhizome growth dominating during the late summer peak.

New shoots are produced from the underground rhizomes in early spring, typically in February or March. Shoots which emerge in spring survive for that season alone, whereas those emerging in autumn generally persist into the next season.

RCG is one of the first wetland plants to emerge in the spring, enabling it to shade out native species that emerge later in the growing season. Beginning growth early in spring, RCG emerges shortly after orchard grass (*Dactylis glomerata L.*), but before either bromegrass (*Bromus inermis* Leyss.) or timothy (*Phleum pratense L.*).

Rhizomes grow throughout the summer, developing from buds in the axils of scale leaves on old rhizomes. The elongated stem bears up to nine leaves and supports a

[1] https://www.cotswoldseeds.com/

spike-like panicle. The panicle spreads out during flowering (in early summer) to allow cross pollination, then contracts as the seeds develop.

Reed Canary Grass in the height of summer. Photo courtesy of Alison Barrow, Senova[2]

Seeds mature from the top of the panicle downward and drop off as soon as they ripen, making them difficult to harvest. RCG seed is small (1.1 million/kg) and shiny, varying from yellow to light grey or black.

Because RCG needs exposure to a cold period to enhance seed production ('vernalization'), regrowth after the first cut remains vegetative, leafy, and suitable for grazing.

[2] https://www.senova.uk.com/

2. Pre-planting

2.1 Site selection

2.1.1 SUITABLE SOILS

RCG grows well on most types of soils; it is one of the best grass species for poorer soils and is very tolerant to flooding. It thrives particularly on wet humus-rich soils where it gives the highest yields and best quality of biomass.

It is more drought resistant than many other grass species (even though it grows naturally in wet places), and the optimum pH is 6-7.

Heavy clay soils lacking humus are less suitable for establishment and early growth.

2.1.2 WATER AVAILABILITY

Annual rainfall and soil water retention will strongly influence the yield of RCG at any site. RCG possesses good water use efficiency when considered based on the amount of water required per unit of biomass. Additionally, roots can penetrate and extract water to a depth of around 2m.

Summer drought can result in yield loss due to soil water deficiency. This will reduce yield in the year of drought, but the crop will survive and re-grow the following year. It does not require irrigation but makes an excellent filter for dirty water such as liquid cattle effluent or dairy parlour washings.

2.1.3 TEMPERATURE

RCG is native to the UK and widely distributed and suited to cool and wet conditions. Most varieties grown in the UK can also be found in Canada and Sweden and are therefore frost, ice and snow-tolerant to a far greater degree than that experienced in the UK.

Like other rhizomes, temperature below 6°C will prevent growth, and late frosts may damage early shoot growth, but this will re-shoot as soon as the temperature rises.

2.1.4 SITE ACCESS

The optimum time for 'green harvesting' is autumn or 'brown harvesting' in late winter/early spring (See Section 5.1). The soil conditions can be very wet at these times and the wettest periods should be avoided. Irrespective of soil type, it is essential that the soil does not get excessively compacted during any harvesting periods as this may limit accessibility for harvesting machinery and cause damage to the soil structure.

Hard access is therefore advisable to support the movement of harvesting machinery and harvest material to and from the site.

2.1.5 SUITABLE LAND AREA

The species is both drought and flood tolerant and that opens up many suitable land areas for its growth. RCG has been planted in a variety of sites for trials over the past 30 years, and in a number of farmer-led and research institution-led trials across the UK. On every site, regardless of the sub-strata, as long as the top 30 cm of soil is in good condition, and pH balanced, RCG will grow in all areas that grass would grow in.

RCG has been successfully grown on the following soils in the UK:

- Landfill restoration sites using low grade thin soils (this is more suitable for environmental delivery, as this application is likely to result in low yield)
- Clay, over boulder clays
- Chalky silty loams over chalk
- Light sandy loams
- Clay loam over sandstone
- Stony acid brown earth, and
- Brown sands over clay and limestone.

2.1.6 GEOGRAPHICAL LOCATION IN THE LANDSCAPE

There are no issues with planting locations as the maximum growing height does not exceed two metres and therefore an Environmental Impact Assessment (EIA) is not required. It is suggested that RCG is not planted closer than six metres from a pond or river for commercial production in order that plants native to the waterway can

maintain habitat. This would, in any case, be a stipulation of Local Environment Risk Assessment for Pesticides (LERAP) rules during the initial establishment.

RCG can virtually be sited anywhere the grower wants to plant the crop. However, best practice consideration should be given to:

- Ensuring a minimum of 6m between the crop and the property's boundary is recommended
- Not restricting visibility for road splays
- Leaving at least 3m alongside a footpath or 3m either side of a footpath running through a field
- Leaving access for hedge cutting and/or fencing for in-field maintenance
- Leaving an area unplanted around hedgerows if access is needed to manage those hedgerows
- Turning spaces for machinery
- Not planting directly under tree canopies, as this restricts both light and water getting to the crop
- Any other consideration which might impact on a neighbour in a negative manner.

2.2 Variety selection

The RCG varieties grown in the UK are generally supplied by seed merchants. There are a number of different varieties to choose from, and most have similar vigour and characteristics. Field populations have a high degree of genetic variability, and it has been estimated that more than 115 artificially selected RCG genotypes have been developed.

All RCG seed behaves in a similar manner to other grasses and ripens from the top down and usually unevenly. If RCG is being planted for livestock feed, then low alkaloid varieties such as Marathon or Palaton should be selected. If only used for biomass, and livestock are to be discouraged from grazing, then all other varieties are recommended.

Varieties which have shown promise in trials include Bamse, Chiefton and Palaton. Marathon is the variety of choice to allow livestock a low alkaloid feed source preventing diarrhoea and being grazed or ensiled in the early growth season.

It is difficult to determine the genetic origin of a particular RCG stand, although the presence of both green and purple panicles (grass flowers) in mid-June point to the existence of different genotypes within the stand. This will make little difference to variety selection but is a visual difference.

2.3 Site preparation

RCG should be established as per other forage (whole crop) grass that has small seed and sluggish seedlings. A firm, smooth seedbed should be prepared to:

- Reduce moisture loss from the surface
- Enable uniform seeding depth
- Facilitate moisture movement to the seed, and,
- Ensure the best stand develops.

Rolling, both before and after sowing, is highly recommended.

A good example of a well-prepared seedbed without ploughing

2.3.1 PRE-PLANTING PEST CONTROL

A contact herbicide (e.g. glyphosate or paraquat) should be applied in the autumn before sowing and again several weeks prior to sowing. It is recommended that a qualified agronomist is consulted for each specific location and soil type.

For grasslands with heavy weed presence the first step before planting is to spray the site with an appropriate translocated (systemic) herbicide (e.g. glyphosate 360

g/l product at 4-5 l/ha) to control perennial weeds. This should be undertaken in early autumn when weeds are still actively growing before soil tilth preparation the following year, when conditions are correct.

If necessary, the translocated herbicide can be re-applied just prior to planting. A translocated (systemic) herbicide (e.g. Glyphosate - 360 g/l product at 3 l/ha) should be applied in early spring. Best practice recommends that approx. 10 days should be left between herbicide application and planting.

Non-chemical methods of pest control include mechanical fallowing to reduce weed seed reserves. This can be followed by planting a winter annual cover-crop in late summer/autumn prior to planting, similar to traditional farming practices.

For cover cropping, in addition to removing top growth of any existing weeds, seedbed preparation should include chopping-up or otherwise disrupting the rhizomes, rootstocks, and other below ground structures of perennial weeds. It is vital to make sure that weed seeds are not germinating just below the surface when the cover crop is planted to prevent competition. The final shallow tillage to finish the seedbed should take place the same day, or just before, planting.

Legumes or Linseed are particularly good cover crops. Whether there is limited nitrogen, or lots of soluble nitrogen, winter cereal ryes are good as they rapidly take up and out-compete weeds for soluble nitrogen.

If leather jackets (soil-dwelling offspring of cranefly that eat seed) are an issue, insecticidal control is no longer permitted in the UK. Therefore, cultural practices to reduce crane-fly populations in the late summer/autumnal period should be encouraged, for example cutting tussocky fields (if necessary) to try and reduce egg laying habitats.

Additionally, encourage bird populations using bird friendly hedges and crop borders sown with winter bird food mix (to eat the leatherjackets) before planting. Larvae populations can be reduced through stale seedbed practices.

Again, tillage in early spring before planting can disrupt larvae and expose larvae to feeding bird populations.

2.3.2 SOIL TESTING AND MANAGEMENT

Soil testing should always be undertaken before planting. The pH and Soil Nitrogen Supply (SNS), phosphorus (P), potassium (K) and magnesium (Mg) indices should be screened for and can be adjusted during the site preparation stage if needed. There are multiple soil testing companies which can offer services with in-depth soil analysis and reporting[3]. Even 'field-level' analyses can be provided to help carry out targeted nutrient application. It is also worthwhile sampling and asking for carbon report status on the soil. This service is offered by most soil testing laboratories. If the carbon testing is repeated after four years, and on termination of the crop, the soil organic matter and carbon content of the soil may be much higher from perennial management when compared to annual crops.

Based upon the results of the soil tests, nutrient or lime application, if necessary, can be carried out to adjust the levels to the optimal conditions for RCG. It should be noted, unnecessary fertiliser application may only encourage weed competition during establishment.

Additionally, baseline soil analysis can be used for predictions of nutrient application based on yields, once the RCG has been established.

2.3.3 NUTRITION

Some generally suggested guidelines are detailed below but it is strongly recommended that a qualified agronomist is consulted.

The amount of fertiliser to be given to a crop is an important cost decision and should be based on the cost of fertiliser and the expected gain in yield and quality.

Although RCG tolerates a wide range of pH (4.9-8.3), soils which test below 5.5 could be limed to increase availability of phosphorus, potassium, and several micronutrients.

Heavy rates or split applications of artificial nitrogen to the aftermath growth is not necessary as later in the season, days get shorter and soil drier and growth response to fertiliser declines.

[3] https://ahdb.org.uk/knowledge-library/soil-and-forage-testing-companies

A vigorous stand of RCG may take up to about 30 kg of phosphorus (P2O5), 150 kg of potassium (K2O), and 10kg of sulphur per hectare each year from full yield removal. Replacing this should be considered annually, depending on the crop rotation.

To compensate for this loss, these elements should be added according to soil test recommendations.

2.4 Pre-planting considerations - Rejuvenation/Regeneration

Vigorous stands of RCG are seldom affected by diseases, pests, or weeds. However, productivity of a stand often declines once a continuous sod has formed because the high density of plants and roots increases requirements for nutrients beyond the capacity of the soil to supply them.

To reduce competition, harvest the cereal early for forage. Sufficient RCG usually survives this treatment to re-establish the stand. Stands can also be rejuvenated by ample applications of balanced nutrients from leaf or sap or soil analysis in the growing season.

Renewed interest in RCG occurred recently when waste water management became an important issue. RCG has the ability to respond exceedingly well to applied nutrients and one study showed a yield response to levels as high as 1023 kg N/ha (Schmitt et al. 1999). Zeiders (1976) reported, “RCG is the most popular species for irrigation with waste water from municipal and industrial sources as a pollution control measure.”

If the crop is not harvested in a single year the RCG will die-back, and a new stand will emerge in the following season. This is a real advantage if bi-annual cropping is the preferred method of building up soil organic matter and carbon and is a fallowing method that avoids the need for as many artificial inputs to the soils to replace off-take. Once the crop is returned to cereal production this carbon building soil fertility often enhances cereal yields especially in Year 2 after destruction.

3. Planting

3.1 Planting machinery

Unlike other species of rhizomatic biomass crops, RCG produces small seeds. As long as there is minimum competition from other perennials in the first full year of establishment, these can be planted without inversion tillage of the soil.

For RCG seeding it is possible to use a multitude of devices which may already be available on-farm or provided locally by a contractor. A conventional seed drill can be used into either cultivated or non-cultivated soils followed by a good consolidation rolling. Drills are considered the best method of establishment.

Broadcasting is also a popular, quick and cheap method but it is usually wise to carry out two passes at half rate in double passes over the same ground in order to produce an even distribution. In strong winds this method is not recommended as seed contamination can pass onto a neighbour's land or be spread further afield via watercourses.

Machinery used for planting RCG

A third (more novel) method is to use a boom air seeder which can be up to 12 m in width to blow the seed down into an existing crop of wheat or barley, for example. This can be done up to a month before harvest or even into standing maize if the weather conditions look wet and unsettled for a three-week window.

Finally flying drones are starting to arrive on the market. These are now CAA-licenced to spread RCG on steep slopes by air broadcasting. Drones can also be used for harvesting on steep slopes and carrying the crop up or down the slope to a safe location for processing. Using a ground-based drone to make use of this exciting technology may allow for RCG to be grown in places and harvested where previously only sheep and goats ventured due to the dangerous slopes.

3.2 Timing

The optimal planting time for RCG seed or even rhizome plugs is from March to April when average soil temperatures are >8ºC. This allows an extended first season of growth and takes full advantage of spring moisture. This is important because it enables larger rhizome systems to develop. Seedling establishment is the most critical stage in the maintenance of a good RCG stand. Crops with larger rhizomes are more robust in future years, allowing the crop to better tolerate drought and frosts.

Planting can, however, continue into May and even early June and still be successful. Seeding later than early June reduces forage yield and may eliminate seed production the next year, because juvenile plants will not vernalize over winter.

Seedings delayed until after mid-August will require most of the next growing season to establish, except in moist and mild areas of the UK.

3.3 Planting density

For forage production, RCG should be sown in rows spaced 12.5 cm apart, and at approximately 5-10 kg/Ha.

When the seedbed is rough and/or uneven, when broadcasting, or when seed is of lower germination, seed should be sown at a higher rate. Likewise, in good seedbed conditions, a lower rate can be used.

3.4 Planting depth

RCG seeds should be planted in a shallow furrow, down to a maximum seed depth of 2 cm depending on the equipment used. Seeding too deep is a common cause of crop failure. A cultipacker seeder provides excellent depth control for seed

placement, whilst press drills with depth control attachments also work well. In high rainfall areas, 'broadcasting', then harrowing lightly to cover the seed is also an effective seeding method.

4. Post-planting establishment

4.1 Nutrition and fertilisation

Growers are advised to make use of regular soil tests to determine that sufficient levels of nutrients are available in the soil.

RCG is very efficient in the way it uses nutrients and there are several reasons for this:

- RCG is deep rooted and can extract nutrients from a large area of soil
- RCG has a high nutrient efficiency compared to arable crops (wheat, barley) and native grasses (rye grass). Less nutrients are needed for each kilogram or unit mass of biomass produced by the crop
- Excess nutrients are exported from the above ground parts to the rhizome during the autumn as the leaves senesce. The nutrients are stored in the rhizome during the winter and are used to support early growth of shoots during the following spring.

It is generally not recommended that any fertiliser be applied in the first two years as off takes are low and there should be sufficient nutrients in the soil. Typically, fertiliser application during these years will only promote weed growth which will compete with the RCG and incur additional expenditure on herbicides. However, if deemed necessary through soil sampling and analysis, phosphorus (P) and potassium (K) only fertilisers can be applied in establishment years.

The crop should be inspected regularly for signs of nutrient deficiency.

- A yellow-green colour usually indicates nitrogen (N) deficiency
- Purple tinges on the leaves may indicate phosphorus (P) deficiency
- Browning of leaves beside the midrib may indicate potassium (K) deficiency.

Nutrient off takes are confined to the amount of nutrients in the stems at harvest as nutrients in the leaves are returned to soil.

Final harvest yields (and consequent nutrient off take) will depend on crop productivity. Crop nutrient requirements will ultimately depend on soil type, cropping history and nutrient off take.

Recommendations:

- Check soil nutrient indices before planting, then every 3-5 years
- SNS index, if extremely low (< 2) then nutrient application can occur, however, industry standard is generally not to add N
- Maintain soil at P Index 1
- Maintain soil at K Index 1–2.

Research has shown that nutrient off takes from productive crops (5-6 tonnes dry matter/hectare/year) will deplete nutrients. Fallow years will regenerate nutrients if the crop is harvested in a biennial rotation which can then provide biodiversity, shelter and other natural capital such as carbon offsetting.

Livestock manures and bio-digestate or sewage sludge are also an option in terms of meeting the nutrient requirements of RCG. Livestock manures are governed by RB 209 in the UK. For example, cattle slurry can be used as an effective nutrient source for RCG and can be applied annually to satisfy crop nutrient requirements. It is also possible to use a dirty water applicator to spray watery slurry into the RCG crop especially in the growing season. However, this is only permitted if the crop is not to be used as livestock feed and only as biomass fuel.

4.2 Pre-emergence weed control

Weed control is essential in the establishment phase of the crop because the slow initial growth of RCG reduces its ability to compete and infestations can severely inhibit the development of the crop. It's vital that proposed sites should be cleared of perennial weeds before any planting takes place.

The planting process causes soil disturbance which promotes seed germination. Likewise, the low planting densities which are used results in large unoccupied spaces where weed growth can occur.

Weeds, if not controlled, will compete with the crop for light, water and nutrients, and reduce yield. The level of weed interference will depend on the:

- Stage of maturity of the crop (i.e. its ability to out-compete weeds)
- Degree of weed infestation at the site, and,
- Diversity of the weed species (affected by location, season, climate and previous land use).

Once the full canopy develops, the germination of new weed seedlings is dramatically reduced; only shade tolerant varieties (such as black-bindweed and chickweed) or particularly mature, deep-rooted weeds will survive.

Grass can present problems after crop senescence has occurred in the establishment year and should be monitored. Grass weeds can be suppressed by mechanical mowing just above the RCG seedlings.

Before the use of any chemical product, growers should refer to the Off-Label Extension of Authorisation for Minor Uses (EAMU) databases provided by local governing bodies and always adhere to the directions for use on the instruction sheet – it is an offence to use products in a manner that has not been approved. It is recommended that a qualified agronomist is consulted for each specific location and soil type.

4.3 Post-emergence weed control

Once shoots have emerged, selective herbicides may be used for the control of vigorous annual dicotyledonous weeds. Broadleaf weed species can be controlled with common herbicides. Spring cereal broadleaf weed herbicides can generally be used on RCG. These include mecoprop-P and fluroxypyr. A weed wiper may be used to apply post-emergence round-up to the taller, more persistent weeds such as thistles.

Inter-row cultivators can be used for the removal of weeds between rows. Weeds are most susceptible to damage when in their two to four leaf stage so controlling weeds must occur when weeds are young.

From pre-planting to establishment, fields planted in RCG should be walked regularly to check for herbivore and leatherjacket damage. Weed populations must be monitored and remedial action taken when necessary.

The surrounding fields should also be monitored on a regular basis to check for the presence of RCG volunteers, which can be controlled via two approaches:

- Herbicides used to control grass weeds in cereal crops or,
- Application of a broad-spectrum herbicide after the previous crop has been harvested.

Control in pasture is more difficult; cutting and mowing to prevent flowering is possibly the best strategy to prevent flowering and further spread.

There is little experience to quantify the extent to which RCG can be expected to spread. However, it is well established that RCG is more invasive than other crops and constant monitoring of volunteers outside of the crop boundaries is advised.

4.4 Possible pests and diseases

When compared to Miscanthus and Switchgrass, RCG has been found to be no more or less susceptible to pest attack. These guidelines can only point out the known pests of the crop and, as with establishing any new crop, a complete or partial crop failure should be planned for in any financial assumptions.

Aphids and leaf miners can attack RCG, and on occasion, significant yield reductions can be caused by the larvae of various insect species (which kill the stems by feeding inside their base). Additionally, stem damage can be associated with double-lobed moths and fruit flies. Grazing by rabbits and slugs can also be problematic, particularly in the establishment year.

Diseases have been reported on RCG, although not at levels which might cause concern. These include:

- Brown rust
- Mildew
- Buff spot
- Powdery mildew and
- *Rhynchosporium* (leaf scald).

5. Harvesting

5.1 Timing

The optimum time of harvest is generally decided by the weather conditions during the whole winter period.

Once established (Year 2 onwards), RCG starts growing in February and matures in July. After growing vigorously during the summer, RCG stops growing during autumn. The stems dry as the winter proceeds, reaching a moisture content of <16% the following spring. The over-winter period allows the crop to dry, avoiding the need for expensive artificial drying. Combustion quality also improves over the winter period.

- RCG for 'brown' use (i.e. combustion, animal bedding, and construction etc) is harvested annually during late winter/early spring, typically with conventional farm machinery.
- 'Green' harvested RCG (used for anaerobic digestion, biofuels, and fodder/ensiling etc) can be harvested annually in early spring/summer.

Bioenergy (combustion) crops are typically left in the ground over the winter period and harvested the following spring. Harvesting before growth starts in February is recommended to avoid the inclusion of new growth in the harvested material and a consequent deterioration in biomass quality. Delaying harvesting (March/April) can also damage the new growth of the emerging crop.

The calorific value of biomass increases with decreasing moisture content and harvested biomass with lower moisture content is easier to store. Harvesting RCG in wet conditions (regardless of the season) can produce a product with high moisture and leaf content which will be unsuitable for many applications as it will rot.

5.2 Machinery

RCG can either be harvested using conventional grass-harvesting machinery (mowing and baling) or alternatively 'cut and chipped' using a forager equipped with a standard header.

5.2.1 MOWING AND BALING

The crop is typically mown first before being baled. The crop can be cut with a conditioner mower. Front mowers tend to work better than towed models to prevent the tyres crushing the crop below the pick-up point on the baler (which need to be fairly high to prevent scalping).

Baling Reed Canary Grass

There are a number of different types of balers, each producing different bales (e.g. rectangular, round and compact rolls) suitable for different scales of energy combustion. Large rectangular and round balers can produce bales with a dry matter density of between up to 190 kg/m3 and weighing between 250 and 600kg. These balers generally have a capacity of 1ha/hr.

Dry RCG must be picked up immediately. If left on the ground, there is a danger of soil moisture and dew/rain entering the dry product.

Bales can potentially be left in the field for up to 48 hours but immediate removal for further processing or storage is strongly recommended as it is usually cut in the winter months. Optimum moisture content for storage is <16%.

5.2.2 CHIPPING

RCG can be 'cut and chipped' in one operation using a forager equipped with a Kemper or standard header. This method of harvesting involves one operation whereas two operations are involved when the crop is mowed and baled.

'Cutting and chipping' produces a product in chip form which may be suitable for combustion in boilers and power stations.

Harvesting RCG with a forager in order to produce chip

It is important to set the harvester to produce a chip size of 30-40mm. This can be achieved by adjusting the speed of the feed rollers and/or by reducing the number of knives on the drum. Smaller chip sizes have a greater tendency to heat during storage while larger chip sizes are likely to be unsuitable for the intake systems of boilers and power stations.

5.3 Quality

To ensure the best quality of product, it is important that RCG is harvested at the correct moisture (<16%) and stored in a suitable manner to keep it dry.

If RCG is harvested at >16% moisture content, then it should be stored in a dry shed with air flow to allow further drying to a stable moisture content or force dried immediately preferably using RCG fuel to assist in the dying process or another renewable fuel source, rather than fossil fuels.

Any layers of RCG cut below 10 cm ('scalping'), which gather on the ground under the crop over winter, should not be harvested. This clumpy material is generally excessively wet as it is in direct contact with the soil and doesn't dry easily. The material will also be decaying, mouldy, and will have a high probability of containing soil or small stones. All of these things are detrimental to combustion or processing equipment. Inclusion of this material could lead to an increase in both moisture content and ash content. It could also contribute to higher chlorine levels which are undesirable from a combustion viewpoint within the harvested material.

Nesting birds and small mammals might also survive below the blades of the machinery. Additionally, nutrients within this leaf layer provide nutrition for succeeding crops. Consequently, mowing height and the height of the baler pick-up should be set to avoid picking up this material.

Additionally, it is important that mown windrows are not raked together as this will gather any decaying leaf material that will have fallen from the plants over the year and through the winter whilst drying.

If it is possible to rotate areas (even in the same fields) and not harvest everything at once, then biodiversity will be protected for future years. This will appeal to environmental delivery projects but are in no way mandatory if yield and economics are critical.

6. Post harvest

6.1 Yield

Yields will vary according to age of the crop and environmental factors specific to any one site.

The crop takes one to two years to establish and reach full yield potential and can then remain productive for up to ten years after which its productivity declines. Once established, it can produce five to six tonnes of dry matter/hectare if managed correctly.

The yield from the first season's growth may not be worth harvesting. Allowing it to set more seed may thicken the crop for the future.

If certain RCG varieties are chosen, then evidence from Canada shows it is possible to take a crop of grass off the field but allowing livestock on the field should be discouraged during the establishment year. Please ask your advisor or vet for specific advice on animal health with regards to grazing, silage or hay production of RCG.

From Year 2 onwards, the crop can be harvested annually. The Year 2 harvestable yields may range from five to six tonnes/dry matter/hectare, and those in Year 3 may achieve similar yields (estimated UK average). Harvestable yields reach a plateau after two to three years.

Reasons for variation in the 'yield-building' phase and 'yield in the plateau' phase depend on planting density, soil type and climate. Where water supply or exposure limits yield, the 'yield-building' phase may be longer.

6.2 Drying

Chipped material harvested at high moisture content (>16%) should be spread to a depth of one to two metres on a drying floor with pedestals in place to allow efficient air dispersal. The chip should be dried intermittently with heated air, bringing it down to about 12% moisture content over a two-week period.

If whole bales are to be dried, then ensure that air can circulate around all sides of every bale to maximise the drying effect and avoid wet spots forming. It may be necessary to turn bales over during drying if this process is not even.

6.3 Storage

The best way to retain the quality of the RCG product is to treat it like any other biomass material i.e. wheat, barley and oilseed rape straw. To have the driest material possible (which means higher energy value per tonne, and less moisture penalties or possible rejection) it is best retained by being kept undercover immediately after harvest. Storage should be in the form of a bale, pellet, chip or briquette so immediate post-harvest processing is necessary. The choice of dried stored RCG product will ultimately be decided by the end user or buyer (i.e. the person you're selling it to). Chipped material harvested by a forager and deposited on a drying floor should be dry enough for further processing. It is advised not to pile up a large mound of chipped material which could self-heat and rot before there is time to dry it.

6.3.1 STORAGE OF BALES

Once harvested, bales should be stored inside a shed or outside under cover. Baled RCG can be stored in a dry shed for significant periods of time.

Large round bales of RCG stored in a barn

Outdoor storage during the drier seasons is possible; however, if moisture levels begin to increase in the bales, quality can reduce drastically and rapidly. Covered storage will ensure that bales will continue to dry whereas bales stored without cover will deteriorate particularly if conditions are poor.

When storing bales, remember to consider:

- Security to satisfy insurance requirements
- Accessibility for lorries
- Distance from power lines
- Free draining ground or ideally a concrete or hardcore pad
- Good level site
- Free from holes, ditches, and other obstacles.

6.3.2 BALE DENSITY

Growers should ensure that the bales are baled to the correct density and shape. When baling is in progress it is important to physically check the bales at the start of the operation and monitor them at intervals throughout the day. Good, tight bales

should feel hard when kicked and it should prove difficult to get a hand under the strings and lift the string to any distance. It should not be possible to pull the strings off a bale by hand.

Some of the problems of not having the product baled correctly include:

- More broken bales when clearing fields, loading trailers and trucks etc
- Increased baling cost (as more bales than needed may be produced)
- Excessive bale damage from handling equipment
- Hard to achieve a tidy stack and build to a sufficient height
- Excessive use of indoor storage space
- Increased haulage costs per tonne of material due to inability to achieve maximum allowable transport weight
- Possible rejection at processing site.

6.3.3 BALE HANDLING

Having the correct handling attachment on the telescopic handler or loader will ensure ease of operation and enable efficient loading for the haulage company. Haulage companies generally prefer the bales to be loaded lengthways along the vehicle bed. For this to be achieved when loading the vehicle, at least a two-pronged spike should be used, which can handle at least a couple of bales at a time. The more favourable alternative to this is possible, would be a multi-bale grab. This type of loading grab is generally safer and considerably quicker to use. It is important to plan any bale handling well in advance.

6.4 Transportation

Transportation of bales will be subject to restrictions on load dimensions and weight. Weights should not exceed a reasonable weight, having regard to the engine capacity, brakes, tyres, and general construction of the vehicle.

If RCG is turned into pellets or briquettes, then standard HGV Bulker Lorries or tractor trailer units for shorter deliveries can be used. These are often found on-farm or supplied locally by a contractor.

Square or round bales are the most common forms in which straw materials are traded on fuel markets. Even so, the bulk volume of bales restricts the trading area; from practical experiences in Ostrobothnia in Finland, for example, the maximum

transport distance for RCG bale deliveries to power plants whilst maintaining profitability is 80 km (Pahkala et al., 2008).

Briquetting, or pelletizing, are ways to further reduce bulk volume if the end user requires it and should be costed in. The bulk volume reduction from round bales to pellets is ten-fold, and hence, the energy investment associated with the mechanical work involved in the compaction processes may be regained in reduced storage and transportation costs to the end user.

In addition, briquettes, and especially pellets, have advantageous bulk properties and can be handled rationally in transport, storage, loading, feeding systems, etc. The superior bulk properties of pellets compared to wafers and briquettes are probably the main reason why pellets dominate the solid bio energy market and have become a commodity, traded world-wide.

6.5 Site restoration

RCG can only be removed by chemical methods. It is recommended that a qualified agronomist is consulted for each specific location and soil type.

RCG can be effectively removed from an existing site by the application of a post-emergence non-selective herbicide such as glyphosate. When mixed with water at a 2% solution, glyphosate can be applied to growing RCG to kill it actively. Adding a non-ionic surfactant may also help the plant absorb the glyphosate more easily. It's essential to be aware that glyphosate will also kill any other grasses or plants it comes into contact with, so care should be taken to avoid spraying desired vegetation. When used correctly, glyphosate can be an effective tool for controlling RCG.

Under no circumstances should the soil below a depth of 3-5 cm be disturbed for a 12-month period as further flushes of shoots from surviving rhizomes will emerge. Shallow ploughing may not bury any surviving rhizomes and they might re-emerge.

The break crop selected in this destruction phase should allow for maximum use of grass control products (such as graminicides). The crop should be allowed to green-up after harvest or topping, and then, before the new green shoots are 20 cm high (Mid - late May), spray with glyphosate (360g/l product at 5 l/ha).

Broadleaf crops would be the most sensible break crop in this ‘clean up’ year including beet, oilseed rape and linseed type crops which are resistant to graminicides, for example.

7. Flood management regime

When RCG is going into dormancy or already dormant and is no longer green, flooding does not appear to be an issue. The very nature of the rhizome root mass can support harvesting machinery in early spring despite winter flooding, and invariably flooded crops always yield well due to the availability of water for longer periods of time.

Many growers might receive payments from public or private sources to plant RCG to buffer water sources from run off and pollution. These captured and filtered soil sediments will feed the RCG prior to a harvest at the next opportunity.

8. Advantages and disadvantages

8.1 Advantages

- RCG is easier to establish than other bioenergy crops although good seedbed preparation and timely weed control is still necessary during the establishment phase
- Establishment by seed makes RCG less expensive compared to woody biomass crops such as poplar or willow which are established from cuttings, and Miscanthus which is established by rhizome
- As it can be grown on ‘marginal land’ this minimises competition with food crops. It is possible to make use of non-agricultural land or marginal land that is uneconomic for food production

- RCG may be more suitable as a bioenergy crop in areas where soil conditions are not ideal for Miscanthus or willow
- When grown to be used as a bioenergy crop, sowing and harvesting can be carried out using typical machinery used for grass cultivation, avoiding the need for specialised equipment
- Minimal agricultural chemical and nutrient requirements lead to:
    - improved water quality
    - less nitrate leaching
    - greater biodiversity
    - a reduction in soil erosion between rivers and streams in arable fields and,
    - an increase in the organic matter content of the soil.
- Growing RCG lessens the effect of climate change for two reasons.
    - First, the crop absorbs carbon dioxide from the atmosphere and stores this carbon in the soil; this reduces the build-up of greenhouse gases in the atmosphere. Carbon storage rates for greenhouse gases exceed those of annual crops by as much as 20-30 times.
    - Second, the use of RCG as a fuel avoids the need to use fossil fuels. Burning fossil fuels releases carbon dioxide, a greenhouse gas, into the atmosphere and this has been largely responsible for global warming. Burning bioenergy crops also releases carbon dioxide into the atmosphere but this carbon dioxide is reabsorbed by the plant during the following growing season. Some greenhouse gases are released during the production of RCG and during its transportation. However, the use of RCG as a source of energy results in substantially lower emissions of greenhouse gases compared to the use of fossil fuels.

8.2 Dis-advantages

- Seeds of RCG are generally rather slow to germinate and weed competition can be a problem in the first year
- On normal agricultural land the dry matter yield from RCG is expected to be lower than other biomass crops at approximately 5-6 t/ha/yr. As a result, the land resource efficiency is less than willow or Miscanthus (you would need more land to produce the same amount of biomass).
- Lodging (the displacement of stem and roots of plants from their proper and vertical placement) can be problematic in areas which are unsheltered and/or

experience high wind. This can result in wet patches during harvest which can reduce the quality of the crop

- If winter weather leaves the crop too wet or the soils too wet, it may not be possible to harvest RCG in a timeframe for high productivity. Equally in a varying climate the same could be said of summer crops.
- RCG is an invasive rhizome and therefore its ultimate destruction (if that is the aim) post cropping should be given serious thought prior to planting and given due consideration dependant on land use rules.

9. Legislation

9.1 Growing RCG

There is currently no legislation relating to planting RCG. DEFRA class RCG as a 'permanent crop' which is technically incorrect as it is a grass, rather than a tree, shrub or bush grown from a stem. It can also be returned to an arable or annual grassland rotation within 12 months.

This may change as Basic Farm Payment is phased out and Environmental Land Management Systems (ELMS) and Sustainable Farming Incentives (SFI) (and equivalents in devolved regions) are introduced.

9.2 Combustion of RCG

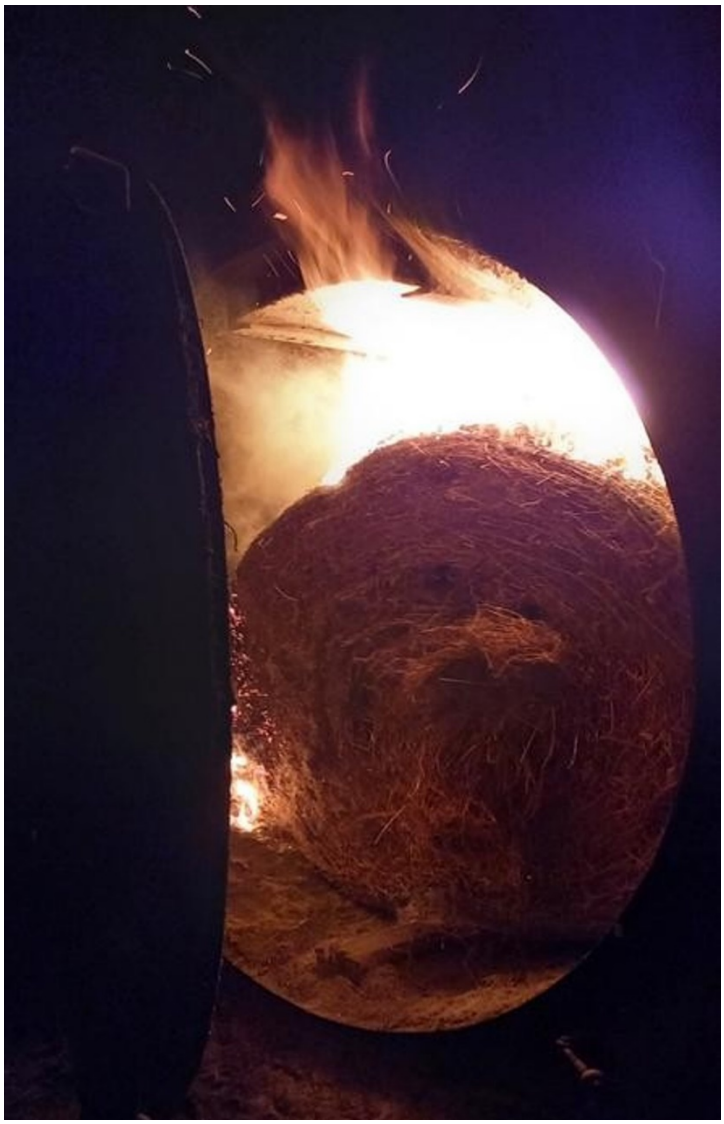
The rules surrounding combustion of RCG, and other biomass crops is quite complicated and depends on whether you are involved in a government backed scheme (Renewables Obligation (RO), Renewable Heat Incentive (RHI), Boiler Upgrade Scheme (BUS) etc) or not. Biomass Connect ran a useful webinar on this subject and there is a recording available online[4].

Typically, if you are using RCG as a fuel for heating and your boiler system is accredited under the Non-Domestic RHI, then you will need to meet the sustainability criteria. The easiest way to remain compliant is to sign up to the

[4] https://www.youtube.com/watch?v=I8C109px77w&ab_channel=BiomassConnect Slides are available at https://www.biomassconnect.org/wp-content/uploads/2023/03/Webinar-4-The-Regs.pdf

Sustainable Fuel Register[5] which provides a way of keeping all your fuel records online. (It is also possible to self-report directly to Ofgem).

In addition, unless your biomass boiler was installed before September 2013 it is likely that an emissions certificate will be required. This needs to be specific for your boiler and its kilowatt rating with RCG fuel specified as a chip, pellet, briquette or bale. There are currently no fuel quality requirements, but you do need to keep records of amounts of fuel used and its moisture content.



Combustion of large round bales of RCG in a batch fired biomass boiler

[5] https://sfregister.org/

Combining a Reed Canary Grass crop

Disclaimer

This Best Practice Guide has been collated from various sources based on the most current information available. It is only a guide and for specific technical advice subject matter experts should be consulted. The authors accept no liability for implementation of these practices when through unforeseen circumstances the recommended outcomes are not achieved. Throughout this publication, reference is made to a number of pesticides (herbicides, fungicides and insecticides) which have been used either commercially or experimentally in reed canary grass production. It should be emphasised that with any pesticide application the relevant legislation (Health and Safety at Work Act 1974; Poisonous Substances in Agriculture Regulations 1984; Food and Environment Protection Act 1985; Control of Pesticides Regulations 1986; Control of Pollution Act 1974; Plant Protection Products (Sustainable Use) Regulations 2012 etc.) and the Product Label Recommendations must be adhered to.

Funded by DESNZ

Department for Energy Security & Net Zero

Project collaborators

Crops for Energy

afbi

NFU ENERGY

CALVIUM