USE OF BIOMASS FROM REED CANARY GRASS (PHALARIS ARUNDINACEA) AS RAW MATERIAL FOR PRODUCTION OF PAPER PULP AND FUEL

B. Andersson[1] and E. Lindvall[2]
[1] Svalöf Weibull AB, S-268 81 Svalöv, Sweden
[2] Svalöf Weibull AB, Box 4097, S-904 03 Umeå, Sweden

ABSTRACT
Reed canary grass (*Phalaris arundinacea*) has been investigated as a potential industrial crop in Sweden and other European countries. Reed canary grass (RCG) can be used as raw-material for paper pulp or as biofuel for combustion.

A new harvest method, the delayed harvesting system, was developed which makes it possible to get dry, ready to store, material. The method reduces cost and improves quality of the product. The use of RCG as an industrial crop requires a completely different quality compared to forage. The important part is the cellulose while protein and mineral nutrients are disturbing the process both as a fuel and in fibre production. Different botanical parts of the plant have different quality; it is possible to further improve quality by fractionating and processing.

So far all experiments have been conducted with varieties of RCG developed for forage use. A plant breeding programme has been started aiming at varieties suitable for the new area.

KEYWORDS
Reed canary grass, biomass, biofuel, paper pulp, quality

INTRODUCTION
In order to reduce the overproduction of food large areas of agricultural land have been set aside in Sweden. Strong political forces want to stop using nuclear energy from year 2010. The new energy production systems to replace the nuclear energy must not increase the emission of CO^2 to the atmosphere. The Swedish paper industry makes use of long fibres coming from soft wood and short fibres coming from mainly birch to produce high quality printing paper. In the Swedish forests there is a deficit of short fibre raw material leading to an import of about one third of the need.

With this background, there has been a search for new crops or alternative use of traditional crops in Swedish agriculture.

During the eighties several projects were initiated to evaluate different crops and their potential for agro-industrial use. As a result of these evaluations reed canary grass (RCG) was found to be one interesting species (Tuvesson, 1987; Berggren, 1989).

Further investigations have started to evaluate technique for growth and harvest, quality, processing and to start plant breeding. One project is an international co-operation between partners in Sweden, Finland, Denmark, Germany, Great Britain and Ireland. This project is financed by EU (AIR3 CT94 2465).

GROWTH AND HARVEST
The reasons for the interest in RCG as an industrial crop can be summarised as follows. Technique for grass production is well known among farmers and machinery and buildings are available. Growing grass makes it easy to go back to food production without a big investment in restoring the land, which would be necessary after i.e. tree plantation. RCG keeps the landscape open and the crop can be grown in an environmentally and economically sound system with low nutrient input to the crop.

When producing raw material for the industry the material must be transported from large areas and stored for use during the whole year. For economic reasons it is not possible to dry the harvested crop artificially and weather conditions makes field-drying very difficult in late summer, when the biological production is high. To solve this problem a new production system - the delayed harvesting system, has been suggested (Olsson, 1994). In this system the crop is harvested only once a year and this harvest is delayed until spring the year after the production year. In Sweden this means harvest in April-May, when the snow has melted and it is possible to drive with the harvest equipment, but before the new growth starts. It is then possible to get a dry matter content of 85-90 % without any artificial drying and a crop ready for storage. There is, however, a loss in dry matter because of degradation of the crop during the winter; this loss has been estimated to about 30 %.

The amount of nutrients removed with the harvest in spring is about half the amount removed if harvest is done in August (Landström et al., 1996). This means that plant nutrients can be recirculated and reduce the need for fertilizer application. The loss of nutrients is also beneficial for the quality of the raw material.

QUALITY REQUIREMENT
The use of RCG as biofuel or fibre raw material requires a completely different quality compared to forage. When RCG, or any straw material, is used as fuel for combustion the main problems are related to the ash. The amount of ash is high compared to firewood -it melts at low temperature and cinders (Burvall and Hedman, 1994). A high silica content is the main reason for the high amount of ash. The melting point is correlated to the content of minerals, mainly potassium. High content of chlorine causes corrosion.

RCG used as raw material for short fibre pulp production gives a pulp comparable to hardwood. The number of fibres per unit weight in the pulp is high, which is an advantage with regard to printing properties. The content of lignin is lower than in wood which makes the grass fibres easy to cook. RCG fibres have good bonding properties due to the high hemicellulose content, which gives pulp with a higher tensile strength than birch. The strength of a fine paper handsheet containing agrofibres is comparable with a corresponding birch handsheet. RCG can be used in fine paper and top layer of board, requiring good printing properties from pulp. RCG also has good absorption capacity and may therefore be used in tissue (Paavilainen and Torgilsson, 1994).

Grass is more heterogeneous as raw material than wood, containing a high percentage of fines (very short fibres). The amount of fines as well as the length of the fibres differ in different parts of the plant. The internodes show the longest fibres and the lowest amount of fines. Due to the relatively high amount of fines and the high hemicellulose content, dewatering RCG pulp is more difficult than hardwood pulp. The high silica, potassium and chlorine contents interfere with the recovery of pulping chemicals and may cause major difficulties.

The plant composition (chemical and physiological) changes with development stage of the plant, and pulping properties will change

with the harvesting time. When the plant matures, the cellulose, hemicellulose and lignin content increase whereas the content of undesired components like protein, potassium and chlorine decrease dramatically. It is therefore obvious that RCG for use as biofuel or fibre raw material should be harvested as late as possible. Delayed harvest decreases the potassium and chlorine contents to acceptable levels but the silica level is still high. Research work is going on in different laboratories to develop methods to remove silica from the pulping chemicals. The highest relative pulp yields are achieved if the delayed harvesting system is used and the lowest if the grass is harvested in the summer. Pulp dewatering can be improved by using delayed harvest or by fractionating the grass before pulping by removing the leaves. When the leaves are removed the silica content also decreases.

PLANT BREEDING ASPECTS

A new field of application for grasses - biofuel and fibre - also means that we need a new type of plant material, different from forage grasses. The chemical quality of the biomass has to be different, and the plant morphology as well. The idle plant has a high stem/leaf ratio, high content of fibre and low content of ash, silica, potassium and chlorine. A RCG breeding program was initiated by Svalöf Weibull in 1989, aiming to develop new varieties with characters desirable for an industrial crop. The most important condition of successful plant breeding is that there is some genetic variation in available plant material for the character you want to change. The first part of the RCG program has been a comprehensive screening of local wild material and some commercial varieties from other countries for variation in different characters. A very large morphological variation has been noticed within the species. Variation in chemical components of interest has also been found. It should therefore be possible to develop special varieties of RCG for biofuel and/or fibre purposes.

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