REED CANARY GRASS *(PHALARIS ARUNDINACEA* L.*)* IN NATURAL BIOCENOSIS OF LATVIA, RESEARCH EXPERIMENTS AND PRODUCTION FIELDS

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Abstract
In recent years, perennial grasses have not been considered only as a forage crop but focus has shifted to their usage as an energy crop. Special interest has been caused by reed canary grass, which is widely spread in natural biocenosis. The scientific expeditions have been organized and all regions of Latvia have been explored to gather material and information about biodiversity of perennial species of wild grasses. Several natural populations of reed canary grass (*Phalaris arundinacea* L.) were collected under different soil and climate conditions. The accessions were of different quality in many respects depending on collection site. Samples taken from the marshy meadows on lakeshore of the Lake Lubana were coming into flowers unevenly over a longer period of time and formed a little number of culms, whereas samples collected on the banks of the River Daugava were earlier and formed considerably more culms and were coming into flowers evenly over a shorter period of time.
Breeding on reed canary grass in Latvia has not been done previously. Attention to the wild populations of RCG usually has been focused on their feeding value. Though, these populations have a good potential for selection of a new varieties intended for varied purposes. The field trials with ten wild accessions of RCG were established, and winter hardiness, growth intensity and various phenological observations were evaluated. After a comprehensive evaluation of the wild populations by important economic and morphologic characteristics, some valuable samples were found. The population 'Brigena' proved such valuable characteristics as good winter hardiness, high dry matter yields, and intensive development of productive culms. In recent years, consumption of reed canary grass as energy feedstock has increased rapidly in Latvia. It is grown by farmers in all regions and the total planted area has exceeded 800 ha. Mostly are grown varieties 'Marathon' (USA) and 'Bamse' (Sweden). DM yields obtained by farmers in Latvia on average are 6 - 9 t ha^{-1}. Further research has to be continued.
Key words: energy crop, reed canary grass, varieties, wild populations.

Introduction

Latvia is situated on the coast of the Baltic Sea, in the temperate climate zone, accordingly perennial grasses are the most cultivated plants on the farmlands, as well as they are widely spread in natural meadows, pastures, and other habitats. Areas covered by natural meadows and pastures are 9.5% of the total area of Latvia territory (Boruks, 2004).

Perennial grasses have many characteristics desirable for a good field energy crop: high yield potential, high content of lignin and cellulose. Planting perennial grasses might have positive environmental impact on biodiversity; areas of arable land are reduced ensuring that soil erosion is lowered and carbon content increased, as well cultural landscapes are managed. Previous researches and tests on usage of perennial grasses for biomass production in the Nordic countries has proved that a perennial rhizomatous grass, reed canary grass, is the most productive grass in terms of stable biomass yield in the northern latitudes (Landström and Olsson, 1997; Lewandowski *et.al*., 2003; Saijonkari- Pahkala, 2001). Perennial biomass crops require fewer inputs, produce more energy, and reduce greenhouse gas emissions more than annual cropping systems (Adler *et.al*., 2007).

Numerous studies on reed canary grass usage for different purposes have been conducted in several European countries, in Scandinavia, and in the USA, while in Latvia there have been carried out only few researches on this issue. In recent years, focus has been shifted to reed canary grass as an industrial crop for bioenergy production also in Latvia, where RCG is widely distributed in natural biocenosis. Plant breeding work regarding this specie has not been done previously in Latvia. For this reason, scientific expeditions with the aim to gather basic material and information about biodiversity of perennial species of wild grasses had been organized in all regions of Latvia (Rancane *et al*., 2006). Reed canary grass in wild occurs in meadows on lakeshores, on the river banks subject to overflowing, as well as on other fertile wetlands. Wide areas covered by RCG grass stands were found on the banks of the Lake Lubana and the River Aiviekste, in the meadows that are overflowed by the waters of the River Pededze in springs, on the left bank of the River Daugava, in the areas between the River Suseja and the Lake Brigena, in the areas surrounding the Lake Papes in Kurzeme region, as well as in other places.

There are many different forms of the RCG growing in the wild: from types with narrower and

darker blades to plants having many culms and panicles of spikelets producing more seeds. Reed canary grass has a wide geographic adaptation; genetic variation is present that can be used to select genotypes for specific environments (Cristian *et al*., 1997). For the breeding purposes, there are available samples useful as a forage crop, and the samples with qualities more appropriate for energy generation. New high yielding varieties has to be developed with a quality different from the forage-type varieties. High stem/ leaf ratio, low content of ash and elements like silica, potassium and chlorine are important breeding goals (Lindvall, 1996).

Several natural populations of reed canary grass have been collected in variegated soil and climate conditions in order to test and evaluate the wild material in field trials at the Latvia University of Agriculture Research Institute of Agriculture.

Materials and methods

The wild accessions have been collected mostly from natural meadows, lakeshores, and river banks. Coordinates of collecting places were the following: latitude 56°16-57'N, longitude 26°10-51'E; elevations ranged from 2 to 132 m above sea level. The most proper time for collection of seeds from perennial grasses in Latvia is from the middle of July till the middle of September.

To evaluate 10 wild accessions of reed canary grass, field trails were established at the Research Institute of Agriculture in Skriveri during 2005-2008. The Institute of Agriculture's experimental fields' characteristic conditions are as following: precipitation of 700-800 mm per year, a vegetation period of 160-180 days, and average active temperatures ranging from 1900 to 2000°C. Under the mentioned conditions, two high perennial forage crop yields are commonly obtained; the third harvested yield usually is poor.

The trials for testing of reed canary grass samples were arranged at the field where topsoil was 25 - 27 cm, organic content 1.9 %, pH_{KCl} 5.6, K_2O 78 mg kg^{-1}, P_2O_5 168 mg kg^{-1}. The experiment was comprised of randomized complete block design with 3 replications; the size of plot was 1.2 m^2. Seeds were sowed by hand in the middle of May. Local populations have been named by their area of origin.

In the sowing year, tendency to develop generative browses and diseases resistance before wintering was estimated. In the following spring, the trial plots received fertilizers at the following rates: N = 60 kg ha^{-1}, P_2O_5 = 30 kg ha^{-1}, and K_2O = 70 kg ha^{-1}. In the 1st year of use, winter damages, regrowth intensity in the spring and after cutting, and various phenological observations were evaluated on the 9-point scale (1 - indicates the signs of a weaker expression, 9 - the highest).

The mathematical processing was done by a computer program Microsoft Excel subprogram for analysis of data (Berzins, 2002).

Results and discussion

During study years, from 2005 to 2008, climatic conditions over the vegetation periods and the winter periods in Latvia were different. There were both dry and hot summers, and cool and rainy ones, in the winter time there were periods of black frost. This allowed to

Table 1

Average evaluations of RCG (*Phalaris arundinacea* L.) wild-type populations (2005-2008)

Accession	Winter damages (1-without damages; 9-perished)	Regrowth at the spring (1- slow; 9- rapid)	Heading date	Inflorescences emergence intensity (1-some panicles; 9-uniform)	Plant height at flowering, cm	Total culm number (1-few; 9- very much)	Length of longest culm (1-short; 9- very long)	Susceptiblity to diseases (1-healthy; 9-highly damaged)
Lub K	2	3	18.06	6	135	4	5	2
Osupe	3	2	20.06	8	119	4	4	1
Zvid	2	3	18.06	7	148	5	6	1
Meir K	3	4	18.06	6	117	4	4	2
Krust k	3	5	10.06	6	158	3	7	1
Brigena	2	8	07.06	8	160	7	7	1
Varkava	4	3	18.06	5	120	3	4	3
Suse	5	7	08.06	3	131	5	5	3
Eglaine	3	6	10.06	4	152	5	6	3
Pape	4	8	07.06	4	167	6	8	2
LSD 0.05	0.6	2.0		2.0	15.7	0.5	1.6	1.6

Source: made by the authors

Table 2

DM (t ha^{-1}) yields of reed canary grass varieties

Variety	Harvesting year		On average 2009-2010	% to Control
	2009	2010		
Brigena	9.13	9.41	9.27	100
Marathon	8.06	8.86	8.46	88
Palaton	8.94	9.67	9.31	101
LSD 0.05	0.80	.45	.52	7.7

Source: made by the authors

Table 3

Chemical composition of reed canary grass varieties

Cultivar	1st cut					2nd cut				
	Crude protein, %	P, %	K, %	Ash, %	Digestible protein, %	Crude protein, %	P, %	K, %	Ash, %	Digestible protein, %
Brigena	11.85	0.30	2.29	6.65	45.4	12.07	0.28	1.77	5.72	37.8
Palaton	11.56	0.28	2.05	5.97	44.5	11.94	0.22	1.36	5.01	41.5

Source: made by the authors

multi-examine the wild samples and select the most valuable types for future breeding work. The collected wild-type reed canary grasses were different from each collection sites in many respects. Accessions collected from the marshy meadows near the Lake Lubana are serotinous, they are coming into flowers over a longer period and developing few culms. These types can be harvested over a longer period of time; the process of lignifications is slow, and they are more suitable as a forage grass crop.

Samples collected on the banks of the River Daugava, at the Lake Brigena and the Lake Papes develop more culms, and come into flowers evenly over a shorter period of time. The mentioned qualities offer high potential for use in bioenergy generation.

Assessment results indicated that wild samples, collected from different geographical locations in Latvia, provided higher winter hardiness results. The highest degree of winter-resistance during the 3-years period was showed by such local populations as ‘Lub K’, ‘Zvid’, and ‘Brigena’, they were evaluated with 2 points, suggesting that grass swards of above mentioned accessions had almost no observable damage thanks to their winter-resistance. Results regarding key features of 10 local RCG samples obtained from the collection nursery are summarized in Table 1.

In general, reed canary grass is very winter-hardy, and the genotypes did not have a period of dormancy, whereas dormancy is a normal characteristic of reed canary grass growth in Scandinavia (Olsson, 2004).

There were observed great differences among tested samples in regrowth intensity both in spring, and after cutting, assessments ranged from 2 to 8 points. Varied evaluation of the growth intensity allowed us to select the best samples providing a rapid regrowth in spring and after cutting. There were selected populations, which were evaluated with 7 - 8 points, ‘Brigena’, ‘Pape’, and ‘Suse’, while regrowth intensity of populations ‘Osupe’, ‘Zvid’, ‘Varkava’, and ‘Lub K’ turned out to be slow, and they were evaluated only with 2- 3 points.

Some wild populations distinguished among others with a great number of culms and the tallest culms at the flowering - over 160 cm. These quantitative characters are important for energy grass crops, including reed canary grass. Culms of the tested accessions were 117 - 167 cm tall and some differences were very significant. Taller and hence potentially most productive were the accessions: ‘Pape’, ‘Brigena’, and ‘Krust k’ (7-8 points). At the same time, shorter occurred the samples: ‘Varkava’, ‘Meir K’ and ‘Osupe’, with the length of culms not exceeding 120 cm, therefore they were evaluated with only 4 points.

Intensity of inflorescence emergence among the studied samples varied considerably within 3-8 points. ‘Osupe’, ‘Brigena’ and ‘Zvid’ flourished fast and simultaneously, while populations ‘Suse’, ‘Eglaine’ and ‘Pape’ formed only some panicles and were evaluated with 3-4 points. Since production of reed canary grass seeds is complicated and expensive, the aforementioned feature is essential.

Heading started at the beginning of June. Varieties 'Pape', 'Brigena' and 'Suse' came into flowers fast and simultaneously, while the serotonous varieties came into flowers 10 days later.

Data analysis shows that inflorescences emergence intensity have negative correlation with length of culm (-0.75), but positive correlation appears between regrowth intensity and leaf colour (0.78), and regrowth intensity and length of culm (0.77).

Reed canary grass populations collected in the natural environment proved to be resistant to a number of grass-specific diseases, including leaf mottling (*Drechslera dictyoides*) and various rust (*Puccinia*) species. The most of plants were healthy, with no observable defects.

After the comprehensive evaluation of the wild accessions by significant economic and morphological characteristics, some favourable samples were found and, as a result of further breeding work and purposeful selection, preferable variety 'Brigena' was developed.

All around the world there are well known such RCG forage-type varieties as 'Venture', 'Palaton', 'Marathon', 'Pedja', 'Lara', an industrial variety 'Bamse', recently developed in Sweden, having a DM yield about 20 % higher than forage-type varieties. Variety 'Brigena' was compared with American origin varieties 'Marathon' un 'Palaton' available in Latvia. The new bred variety proved to be multi-purpose plant, it showed such characteristics as good regrowth capacity, tall stems, good leafage, dense stands, and good dry matter yields, exceeding 9 t ha^{-1} (Table 2).

An ideal plant for energy generation has high fiber content and low content of ash, silica, potassium and chorine (Andersson and Lindvall, 1999).

Analysis of chemical composition showed that variety 'Brigena' in comparison to variety 'Palaton' has higher protein, ash, and K content in dry matter; these are considered as significant elements that characterize a good forage crop (Table 3).

In recent years, volume of RCG grown as an energy crop has been expanding rapidly in Latvia. The total area of reed canary grass grown by farmers in all regions has exceeded 800 ha. Mostly grown varieties are 'Marathon' from USA and the industrial variety 'Bamse' from Sweden. The DM yield obtained by farmers in Latvia on average is 6- 9 t ha^{-1}.

Reed canary grass grown in Latvia is harvested in the late autumn, when plants are almost dry. After harvesting, the biomass is allowed for drying, then gathered into big round bales and transported to pelletizing facilities. The average weight of a bale is 250 kg. Variety 'Bamse' has been grown for the pellets production purposes also in the fields of the Institute of Agriculture in a total area of 20 ha. In the first year, in 2010, a very high DM yield of 7.8 t ha^{-1} was obtained (absolute DM yield 6.5 t ha^{-1}). In the next year, in 2011, the obtained DM yield was lower - 6.4 t ha^{-1} (absolute DM yield 5.0 t ha^{-1}), because of deficiency in moisture over the vegetation period of reed canary grass. Data of chemical composition analysis of biomass DM harvested in autumn were as following: ash content was 6.4 % (5.0 % in spring), the highest calorific value (Q) - 17.74 MJ kg^{-1} or 4235 kCal kg^{-1} (data obtained from the spring harvest were very similar, respectively, 17.94 MJ kg^{-1} or 4286 kCal kg^{-1}). Deformation temperature for biomass harvested in the autumn was 1130 ˚C, for the spring harvest – 1250 ˚C, that can be considered as a good result. It was recorded that concentrations of the undesired elements Cl and S were about one-half lower in the spring harvest than in the autumn harvest. With every 1 % increase in ash concentration, the heating value of the fuel decreases by 0.2 MJ kg^{-1}_{DM} (Jenkins el.al, 1996). However, it must be taken into account that biomass harvested in the spring has a high risk to reduced DM yields, and it must be evaluated whether the harvesting in the spring is beneficial in the conditions of Latvia.

Conclusions

There is a great genetic diversity of wild-type reed canary grass in the nature of Latvia.

Combined tests of variance among the populations showed significant differences in winter hardiness, regrowth intensity, total culm number, and inflorescence emergence intensity.

Wild populations 'Brigena' and 'Pape' are characterized by a number of valuable economic and biological features.

A new variety 'Brigena' has a high potential for use in forage and energy production due to high DM yields and qualities necessary for good forage.

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