DEVELOPMENT OF NEW FORAGE GRASS VARIETIES AT THE SKRIVERI RESEARCH INSTITUTE OF AGRICULTURE

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Abstract
Grasses provide an inexpensive source of feed that is high in nutritional value for profitable milk as well as meat production. Permanent grasslands cover most of the agricultural land in Latvia. The Research Institute of Agriculture in Skriveri has successfully established new diploid and tetraploid forage grass varieties. Over the past few years one of the most important goals of the Department of Plant Breeding, has been the introduction of new perennial grass-plant varieties suitable for growing in Latvian soil, weather conditions and ensuring good dry matter and seed yields.
As a result of this work, five varieties of perennial grasses have been created, with all of them having been registered in the European common catalogue of varieties of agricultural plant species. These cultivars are: tetraploid perennial ryegrass 'Spidola' (4n), meadow fescue 'Patra' (4n), meadow fescue 'Silva' (2n), hybrid ryegrass 'Saikava' (4n), early-ripe timothy 'Teicis'. From 2007 through 2017 timothy 'Teicis' is included in the Lithuanian National List of Plant varieties. New varieties: late season timothy 'Varis', meadow fescue 'Vaira' (2n) and *Festulolium* 'Vizla' (4n) have passed distinctness, uniformity and stability (DUS) and satisfactory value for cultivation and use (CVU) testing in Poland and Latvia. In the future we plan expand our work on the creation of cocksfoot and meadow foxtail, all tall fescue varieties for forage and decorative use.

Key words: perennial grasses, plant breeding, varieties

Introduction
Perennial grasses are important forage crops in Latvia and are cultivated in fields, meadows and pastures. With the development and use of new forage preparation technologies, grass breeding as well as research objectives are currently undergoing changes (Jansone, 1999). Grass growers are looking for grass varieties exhibiting high production and that are capable of withstanding multiple cuttings. The Research Institute of Agriculture, a unit of the Latvian University of Agriculture, is engaged in developing perennial grass varieties that see heavy utilization by the nation's forage industry. Before 1996 five grass varieties were bred by the Institute of Agriculture: tetraploid perennial ryegrass (*Lolium perenne*) 'Spīdola', tetraploid meadow fescue (*Festuca pratense*) 'Patra', diploid meadow fescue 'Silva', hybrid ryegrass (*Lolium x boucheanum Kunth*) 'Saikava', early season timothy (*Phleum pratense*) 'Teicis' (Bērziņš, *et al*., 2006).
All introduced varieties have passed DUS and CVU testing and are included in the European common catalogue of varieties of agricultural plant species. In order to be added to a European National List, a variety must have passed DUS testing, with agricultural crops requiring VCU testing. For a grant of Plant Breeders' Rights to be awarded, a variety must be Distinct, Uniform and Stable.
The objective of our work is to develop and characterize perennial grass varieties suitable for industrial agriculture use in the conditions of Latvia. The purpose of this article is to review recent progress and to briefly describe the developed grass varieties.

Materials and Methods
In order to perform the breeding, we established trial plots for different purposes at the Research Institute of Agriculture which is located in Skriveri. Plots for the growth of our grass collection, plots for hybridizations and trials of developed hybrids as well as plots for variety comparisons were established. For variety comparisons we used newly developed varieties, which were comprised of local and foreign grass varieties.
Meadow fescue and timothy variety trial plots were established in sod podzolic sandy loam soil (Luvic Phaeozem, WRB 1998), pH KCl 6.5, plant available P_2O_5 110 and K_2O 204 mg kg^{-1}

(Egner–Riehm), soil organic carbon 21 g kg^{-1} (Tyurins' method). The size of the trial plots were 10 m^2 (1 x 10 m). The trial plots were fertilized with mineral phosphorus and potassium fertilizers 60 and 90 kg ha^{-1} accordingly and nitrogen fertilizer 60 kg ha^{-1} for each grass cut. Trial variants were arranged according to the standard method. In 2003, trial crop yields were obtained in four repetitions. The number of cuts throughout the vegetation period was dependent on the weather conditions; usually 2 to 3 cuts were made.
Timothy and meadow fescue during the 2004 – 2006 period was the dry matter yield, beginning of blossoming proportion in sward after 3-year use in autumn were determined.
Analysis of variance (ANOVA) was conducted using the GLM procedure of SAS (SAS Inst., 1990) at P=0.005 to test the effects of year, location, N treatment, and all interactions.

Results and Discussion

So far, eight varieties of perennial grasses have been developed at the Research Institute of Agriculture. Five of them are listed in the Common EU Catalogue of Varieties of Agricultural Plant Species, with three still being in the test phase (Table 1).

Table 1. List of perennial grass varieties in the Catalogue of Plant Varieties

Variety denomination	UPOV, grant number	Acceptance date in the Latvian Catalogue of Plant Varieties, List "A"
Perennial ryegrass 'Spidola'	1993	2001-2010
Meadow fescue 'Patra'	1999	2001-2010
Hybrid ryegrass 'Saikava'	1999	2003-2013
Timothy 'Teicis'	2001	2002-2011
Meadow fescue 'Silva'	2004	2005-2014
Timothy 'Varis'	2007	Test
Meadow fescue 'Vaira'	Test	Test
Festulolium 'Vizla'	Test	Test

All the formerly established timothy varieties represent an early-ripening class. Currently there is a lack of late-ripe varieties for Latvian farmers. For this reason we started working on developing timothy varieties that are late-ripening. In 2005, we developed and delivered a late-ripening timothy variety 'Varis' for the DUS (distinctness, uniformity, stability) test trial in Poland. The variety was formed by interbreeding the timothy variety 'Dolema' (Germany) x 'Priekuļu 2' (Latvia) x 'Teicis' (Latvia). In 2007 we received a test certificate (UPOV Report on technical Examination (03.12.2007. COBORU Slupia Wielka) indicating that 'Varis' successfully passed the testing. Currently, in Latvia this variety is in the last year of CVU testing. 'Varis' was developed and tested by: P Berzins, S. Bumane, V. Stesele. Variety characterization according to UPOV is in Table 4.
At the beginning of vegetation, timothy 'Varis' develops slowly and flowers at the beginning of July, later than the varieties 'Jumis' and 'Teicis'. It gives a good grass crop - 6.7 t ha^{-1} of dry matter (Table 2), with seeds maturing at the end of August or the beginning of September. This late season variety exhibits abundant leaf coverage and forms nice sward.

Table 2. Competitive trials of timothy

Cultivars, Country Codes	DM yield, t ha^{-1}, average 2 cuts				% from stand-dart	Beginning of blossoming
	2004	2005	2006	average, 3 years		
Jumis, standard LV	6.04	6.90	6.32	6.4	100	9.06.
Teicis, LV	6.34	7.28	6.69	6.8	105	5.06.
Varis, LV	6.31	7.11	6.74	6.7	105	15.06.
Žolis, LT	5.63	6.33	6.17	6.0	94	18.06.
Promisse, NL	6.29	7.15	6.75	6.7	105	10.06.
$LSD_{0.05}$	0.32	0.31	0.29	0.24		

Timothy 'Varis' is suitable for very late season pasture cultivation in grass mixtures with other late season grasses as perennial ryegrass, creeping bent and late season varieties of red-clover. It is additionally suitable for growth in different soil types. In meadows timothy 'Varis' is useful for intensive culture where are 2 - 3 cuts during the vegetation season.

In 2007 the diploid meadow fescue variety 'Vaira' was forwarded to DUS and VCU test trials in Poland and Latvia. The new meadow fescue variety 'Vaira' is distinguished by higher dry matter yields - 6.1 t ha^{-1} (Table 3) as compared to the standard variety 'Arita'. This meadow fescue variety stays longer in the sward, even longer than variety 'Silva'. 'Vaira' is similar to 'Silva' in that it forms leaves five days earlier than the standard variety 'Arita'. In addition, it has larger tillers, their length being up to 85 cm.

Table 3. Competitive trials of meadow fescue

Cultivars, country codes	DM yield, t ha^{-1}, average 2 cuts					Proportion in sward after 3-year use in fall, %
	2004	2005	2006	average, 3 years	% from standard	
Arita 2n, (standard) LV	6.2	5.6	4.0	5.1	100	60
Silva 2n, LV	6.9	6.5	4.3	5.6	108	70
Patra 4n, LV	6.7	6.0	4.0	5.2	102	55
Vaira 2n, LV	7.7	7.0	4.6	6.1	118	80
Arni 2n, EE	6.1	6.0	3.1	4.8	93	65
Sigmund 2n, SE	6.4	5.7	3.6	5.0	97	60
$LSD_{0.05}$	0.34	0.32	0.27	0.24		

In 2008 the new tetraploid festulolium (*Festuca spp. X Lolium ssp.*) variety 'Vizla' was delivered for DUS testing in Poland. Festulolium 'Vizla' is formed partially by fertile triploid fescue and a ryegrass hybrid, which is obtained by colchhicine treatment and tetraploid festulolium selection. Its winter hardiness is average. This is a late season variety, inflorescence emerges around June 15. This variety has good resistance to leaf rust and leaf spot diseases. This grass variety is well suited for silage and hay applications. The grass quality is good and has high carbohydrate content.

Festulolium 'Vizla' can be used for the formation of late season swards as a single culture or in mixtures with late season clovers and other grasses. It is good for silage or hay preparation. Growth is excellent in mineral soils.The festulolium cv. 'Vizla' was developed by P. Berzins, S. Bumane, V. Stesele.

Table 4. Description of timothy variety ,'Varis' according UPOV

UPOV No	National No	Characteristics	State of expression
1	1	Ploidy	hexaploid
2	2	Plant: speed of inflorescence emergence in the year of sowing	absent
	3	Plant: tendency to form inflorescences in the year of sowing	absent
5	4	Plant: growth habit in 2^{nd} year before elongation	medium
	5	Plant: growth habit at inflorescence emergence (in 2^{nd} year)	medium
	6	Plant: natural height in spring (in 2^{nd} year)	medium
4	7	Leaf: width (in 2^{nd} year before elongation)	medium
3	8	Leaf: color (in 2^{nd} year before elongation)	medium green
9	9	Stem: length of longest stem	medium
10	10	Stem: length of upper internode	short to medium
	11	Flag leaf: attitude of blade	sloping to horizontal
7	12	Flag leaf: length	medium
8	13	Flag leaf: width	medium
6	17	Plant: time of inflorescence emergence	late
	18	Speedy of inflorescence emergence	slow
	19	Plant: number of generative stems	many
	20	Plant: tendency to form inflorescences in second cut	absent

Conclusions

Eight perennial grass varieties adapted to the conditions and the agricultural needs of the Republic of Latvia have been developed in the Skriveri Research Institute of Agriculture during last decade.
Two new grass varieties, timothy 'Varis' and festulolium 'Vizla' will be tested for DUS and VCU by the State Plant Protection Service Department this year.
During 2004 - 2006 we tested and compared newest timothy and meadow fescue varieties for different use.
Timothy 'Varis' and meadow fescue 'Vaira' delivers stable grass crops in Latvian conditions.
The new festulolium variety 'Vizla' can be used as a late season grass crop.

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JAUNĀKĀS STIEBRZĀĻU ŠĶIRNES ZEMKOPĪBAS ZINĀTNISKAJĀ INSTITŪTĀ SKRĪVEROS

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Zālāji ir viens no lētākajiem lopbarības veidiem ar augstu barības vērtību piena un gaļas ražošanā. Ilggadīgie zālāji aizņem lielāko daļu Latvijas lauksaimnieciski izmantojamās zemes.
LLU aģentūras Zemkopības zinātniskais institūts ir selekcionējis Latvijas augšņu un agroklimatiskajiem apstākļiem audzēšanai piemērotas jaunas diploīdas un tetraploīdas stiebrzāļu šķirnes, kas nodrošina labas sausnas un sēklu ražas.
Selekcijas darba rezultātā ir radītas 5 jaunas stiebrzāļu šķirnes, kas ir reģistrētas Kopējā Eiropas Savienības lauksaimniecības augu šķirņu katalogā. Šīs šķirnes ir: tetraploīdā ganību airene 'Spīdola' (4n), pļavas auzene 'Patra' (4n), pļavas auzene 'Silva' (2n), hibrīdā airene 'Saikava' (4n), agrais timotiņš 'Teicis'. Timotiņš 'Teicis' no 2007. gada līdz 2017. gadam ir iekļauts arī Lietuvas Nacionālajā Augu šķirņu sarakstā. Jaunā šķirne - vēlais timotiņš 'Varis' ir izgājis AVS testu Polijā un pēdējo gadu Latvijā atrodas SĪN testa pārbaudē. Pašlaik Polijā un Latvijā pārbaudes testus iziet mūsu jaunās šķirnes: pļavas auzene 'Vaira' (2n) un auzeņairene 'Vizla' (4n).
Selekcijas darbs turpinās pie jaunas kamolzāles, pļavas lapsastes un niedru auzenes šķirņu veidošanas.

21ST CENTURY PLANT BREEDING: THE EVOLUTION OF DIRECTED EVOLUTION

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Abstract

Plant breeding began, by default, with human cultivation of plants nearly 10,000 years ago and quickly led to crop domestication as a result of natural selection toward adaptation to the new, cultivated environment. Natural selection, augmented by human preferential harvesting and planting of specific phenotypes, resulted in the creation of many locally adapted, reasonably productive landraces. These landraces were later exploited through the isolation of homogeneous populations of pure lines as varieties; this was concurrent with increased mechanization in planting, harvesting and processing operations. The discovery of Mendel's work at the beginning of the 20th century resulted in the application of genetics to plant breeding and the use of hybridization as a plant breeding tool. Thus 'directed evolution' came into being. New discoveries in genetics through the past 100 years (quantitative genetics, polyploidy, induced mutations, male sterility, understanding of DNA and molecular biology, haploidy, genetic transformation) were rapidly