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Selection efficiency of wild ecotypes for forage and turf grass breeding

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Experimental evidence from the period 1994–2007 suggests that selection of wild forage-type ecotypes is promising for smooth-stalked meadow grass, reed canary grass, redtop and other species. On the basis of wild ecotype selection of these species, four forage type varieties of grasses have been developed: smooth-stalked meadow grass 'Gaja' and 'Danė', redtop 'Violeta', reed canary grass 'Pievys'. About 3% of the forage-type plants of perennial grasses exhibited resistance to foliar diseases. For the development of forage-type varieties of some species, such as timothy and meadow fescue, wild ecotypes were in most cases insufficiently luxuriant.

According to a complex of agromorphological characteristics, about 1.5% of the wild ecotypes of various species were found to be promising for the application in turf grass breeding. Some turf grass varieties have been developed on the basis of the most promising wild ecotypes and have been registered in Lithuania: smooth-stalked meadow grass 'Klotė' and 'Galvė', red fescue 'Gludas'.

Key words: agromorphological properties, natural habitats, wild ecotypes

INTRODUCTION

Until 1994, wild ecotypes were hardly ever collected in Lithuania for the purpose of perennial grass breeding. This resulted from the fact that until 1990 all the required initial breeding material had been provided by the All-Union Institute of Crop Production (presently N. I. Vavilov Institute of Plant Industry). Upon restoration of independence in Lithuania, the links with this institution were practically severed. As a result, it was necessary to start the collection, investigation and storage of the genetic resources that had formed under Lithuania's conditions, since wild ecotypes collected in natural habitats provide a unique genetic foundation for breeding. Moreover, wild ecotypes growing in areas unprotected by the state laws can be irreversibly lost or destroyed.

In West Europe, the conservation work on genetic resources of forage grasses was started approximately 30 years ago [1, 2], while in Lithuania this work was initiated only in 1994, after Lithuanian plant breeders had joined the International Genetic Resources Conservation Programme designed for the Nordic–Baltic countries [3, 4]. During several of implementation periods of National Genetic Resources Conservation Programme (1994–2008) there were arranged 28 expeditions to 326 natural habitats and collected over 1400 seed accessions of the main perennial grass species bred in Lithuania.

Some varieties were created at the Vokė Branch of the Lithuanian Institute of Agriculture by using wild ecotypes of Lithuanian origin. The varieties developed before the setting up of the Genetic Resources Conservation Programme were as follows: reed canary grass 'Alaušas', tall fescue 'Navas', smooth brome 'Barta' and Skalva, cocksfoot 'Dainava' [5].

The objective of the present study was to ascertain the selection prospects of wild ecotypes for most important forage and turf grass breeding over the period 1994–2007.

MATERIALS AND METHODS

The perennial grasses were tested in the Central Lowland of Lithuania with an annual amount of precipitation ranging from 520 to 700 mm, the average air temperature 6.3 °C and the warm period of the year lasting six months [6]. In the autumn of each year of use, phosphorus and potassium fertilizers (P_{60} K_{90}) were applied. Nitrogenous fertilizers (N_{150}) were split-applied each year of herbage utilization in spring (N_{60}) and after the first and second cuts (N_{45}).

Perennial grasses were collected in various geographical terrains of different regions of Lithuania which have remained intact by any human activity for an extensive period of time. Seed accessions were also collected from wood felling grounds, waste land, cultivated meadows and grasslands where human activities had been limited for the previous 25–30 years. In natural habitats, accessions were collected either in the form of seed or plant vegetative parts [7].

During the period 1996–2007, the following numbers of wild and semi-natural ecotypes were tested: 243 of meadow fescue (*Festuca pratensis* Huds.), 212 of smooth-stalked meadow grass (*Poa pratensis* L.), 130 of timothy (*Phleum pratense* L.), 104 of red fescue (*Festuca rubra* L.), 8 of redtop (*Agrostis gigantean* Roth), and 17 of reed canarygrass *(Phalaris arundinacea* L.).

The experimental plots were planted with the greenhouse-grown plantlets of the wild populations of perennial grasses, 16–32 plantlets of each accession at a distance of 50 × 50 or 100 × 75 cm.

The standard was planted on every 10th plot. The experiment was not replicated. The populations were tested for 16 morphological characteristics or agronomically valuable traits. The plants were rated using a 1–9 or 3–7 point assessment scale [8]. The grasses of each sowing year were tested for two years. In the year of use the herbage was cut twice. The first cut was taken at the full heading stage and the second cut was taken 40–50 days later.

The data were processed by the statistical methods using the 'Selekcija' software package [9].

RESULTS AND DISCUSSION

Forage grasses. Research on forage-type meadow fescue and timothy suggested that we did not succeed in finding wild ecotypes possessing all the desirable valuable characteristics. As a result, wild ecotypes can be used in the breeding of these species as donors of specific valuable characteristics for the development of new varieties.

From the viewpoint of plant breeding, it is very important to have varieties differing in earliness, which would enable a wide application of the species. In terms of earliness, there is no marked polymorphism within the meadow fescue species. The difference among the ecotypes that started heading at the earliest and the latest dates was 3 days (Table 1). Wild populations of timothy differed in earliness by 15 days.

According to the incidence of foliar diseases, the wild ecotypes of meadow fescue significantly differed within the species. The ecotypes that were more affected by crown rust were also more severely affected by leaf spots. We did not succeed in finding relatively resistant ecotypes of these species. Only individual relatively resistant plants were identified during our test period. These plants accounted for about 3% of the total plants tested. The yield of wild ecotypes of these species (timothy and meadow fescue) was lower compared with the registered varieties. Productivity tests of meadow fescue revealed a strong relationship between the productivity of a wild ecotype and bunch shape. We noticed that the ecotypes with a more prostrate bunch produced a low or medium yield of the first cut, however, the yield of the second cut was better (Table 1). The wild ecotypes of timothy differed in productivity only inappreciably, however, the productivity of individual plants varied markedly within the population. Very productive plants accounted for 4–8% of separate populations.

The most rapid way to develop novel smooth-stalked meadow grass varieties for forage is to search for wild apomyxically reproducing ecotypes possessing a whole complex of agronomically valuable characteristics. Naturally occurring smooth-stalked meadow grass is characterised by a great diversity of forms with different morphological traits and biological characteristics [10–13]. These wild or semi-natural genotypes are a very valuable gene pool which may be used for improving important breeding characteristics.

Over the ten experimental years we happened to find only two of such forage-type promising ecotypes of smooth-stalked meadow grass. These high-yielding ecotypes were characterised by a great tuft diameter and plant height (Table 2). The wild ecotype No. 1796 (variety 'Gaja') was collected in a meadow on the edge of a forest near Pagėgiai (Šilutė distr.), No. 1720 ('Danė') – on the banks of the river Danė in Klaipėda.

Table 1. **Morphological characteristics and biological properties of wild populations of timothy and meadow fescue (estimated in points)**

Type of genetic resources	Earliness (in days)	Herbage yield		Disease damage	
		1st cut	2nd cut	rust	leaf spots
Timothy					
Registered Lithuanian varieties: Gintaras II, Jauniai, Žolis, Klonis, Dainiai, Obeliai, Vėlenis	55–70	6–9	6–7	1–3	1–5
Wild ecotypes n = 130	53–58	3–5	3–4	3–6	3–7
Mean of the trial	56	4.4	3.1	3.2	4.5
LSD_{05}	1.19	0.71	0.67	0.25	0.16
Meadow fescue					
Registered Lithuanian varieties: Dotnuva I, Kaita DS, Mituva, Raskila, Sigita	47–49	8–9	7–8	2–3	1–2
Wild ecotypes n = 243	47–50	4–8	5–8	3–5	3–5
Mean of the trial	49	6.3	6.7	3.9	3.9
LSD_{05}	0.33	0.66	0.70	0.81	0.68

Table 2. **Comparison of Lithuanian standard varieties and most productive wild ecotypes tested in variety trials**

Variety	Earliness, in days	Tuft diameter, cm	Plant height, cm	Disease damage, points		Dry matter yield	
				Powdery mildew	Rust	t ha^{-1}	%
Lanka st.	44	49 ± 5	42±2	3	3	8.65	100.00
Gausa st.	37	53 ± 6	46±5	5	3	10.50	121.30
Gaja (1796)	48	65 ± 8	53±6	5	3	10.74	124.09
Danė (1720)	47	58 ± 4	51±3	3	5	9.79	113.08
LSD_{05}						2.35	27.16

The new variety 'Gaja' (1796) significantly (by 24.09%) outyielded the standard variety 'Lanka' in dry matter yield (Table 2). 'Gaja' was also slightly more productive (2.79% respectively) than the other standard variety 'Gausa'. 'Gausa' is attributed to the group of early (37 days from the beginning of the growing season to the beginning of heading), 'Lanka' to medium early (44 days), and 'Gaja' to late (48 days) smooth-stalked meadow grass varieties. According to disease resistanse 'Gaja' and 'Danė' negligibly lagged behind the variety 'Lanka' (Table 2). The variety 'Gaja' was registered in Lithuania in 2005 and was included in the Common EU Plant Variety Catalogue.

The selection efficiency of apomictic smooth-stalked meadow grass wild ecotypes for breeding of forage and turf grass varieties coincide with the investigations made in foreign countries, because most of the varieties existing in Europe have originated as individual plant selections collected from natural grass habitats or grasslands [14].

Wild ecotypes can also be successfully used in redtop and reed canary grass breeding for forage. This might have been determined by their good adaptability to poor soil conditions and their 'wilderness', i. e these species have hardly been cultivated and their breeding is done on a narrow scale. However, timothy and meadow fescue are different in this respect. The genes of these species contain specific genes determining nitrogen need. This results from the fact that these species have been cultivated in the world for a very long time and the varieties are bred in the conditions of high agrobackground using state-of-the art breeding techniques.

The redtop and reed canary grass are the species that have a rich diversity of different forms of wild ecotypes in Lithuania. These species can grow under a very broad range of agroecological conditions. They are winter-hardy, resistant to drought and diseases.

The redtop wild ecotype No. 227 (variety 'Violeta') was collected in a meadow near Dreverna (Klaipėda district). The variety 'Violeta' is distinguished by an intermediate date of inflorescence emergence, semi-erect growth habit of bunch and satisfactory dry matter and a seed yield.

The reed canary grass wild ecotype No. 68 (variety 'Pievys') was collected in a meadow near Natigalė village (Kupiškis district). The variety 'Pievys' is distinguished by a greyish-green colour of plants, intermediate date of inflorescence emergence, erect growth habit of bunch and a high seed yield. The variety 'Pievys' can be used as both forage and biomass producer.

Turf grasses. Having collected the wild ecotypes of smooth-stalked meadow grass and red fescue in the conditions specific of turf grass growing (habitats on infertile soils or exposed to heavy wear) there was a greater likelihood of identifying short-growing and tufted forms. However, the test results suggested that taller, forage-type grasses were predominant. The ecotypes of smooth-stalked meadow grass were dominated by plants susceptible to diseases, medium green in colour and wide-leaved. Most of the ecotypes of red fescue had dark green leaves and short rhizomes, however, it was also difficult to find the ones that would be suitable for turf grass in terms of all characteristics within this grass species. We often happened to find genotypes with promising morphological characteristics, but lacking in seed productivity. Only part (about 1.5%) of the wild ecotypes were promising for turf breeding according to a whole set of agromorphological characteristics. Using the individual selection method, the following varieties were developed from the best-performing local ecotypes: smooth-stalked meadow grass 'Klotė' and 'Galvė', red fescue 'Gludas'. Appearance characteristics (decorativeness) of smooth-stalked meadow grass varieties are provided in Figure.

Compared with the Estonian variety 'Esto', the smooth-stalked meadow grass variety 'Klotė' forms a denser sward and is characterised by a better general appearance. The plants of 'Klotė' have narrower leaves and are noted for less vigorous re-growth of herbage between cuts. Late in the autumn the sward maintains a more intensive greenness. The variety produces a satisfactory seed yield. The variety 'Galvė' differs from 'Esto' by wider leaves, earlier growth in spring, lower herbage re-growth between cuts, dark green colour and a higher disease resistance. The benefits of the naturally occurring promising wild ecotypes of smooth-stalked meadow grass collected from natural habitats have been also reported by some authors [13, 15, 16]. Both the wild ecotypes No. 1076 (variety 'Klotė') and No 1101 ('Galvė') were collected in Mituva–Nemunas delta (Jurbarkas district). The varieties 'Klotė' and 'Galvė' have been registered in Lithuania and have been included in the Common EU Plant Variety Catalogue.

The red fescue variety 'Gludas' was produced from the wild ecotype No. 24. This ecotype was collected near Smalininkai at

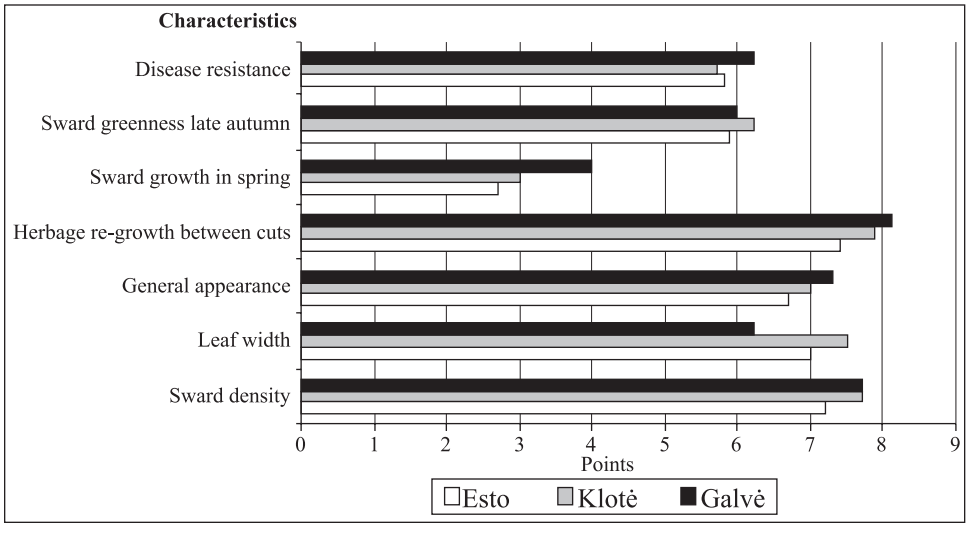

Figure. Appearance characteristics of smooth-stalked meadow grass varieties

the riverside of the Nemunas (Jurbarkas district). Compared with the Danish red fescue varieties 'Pernille' and 'Napoli', plants of 'Gludas' form denser sward characterised by a better general appearance (decorativeness) and narrower leaves. The variety is distinguished by a weaker re-growth of herbage between cuts, earlier growth in spring, and a satisfactory seed yield. The variety 'Gludas' has been registered in Lithuania and has been included in the Common EU Plant Variety Catalogue.

CONCLUSIONS

1. Our tests have shown that for all the grass species tested, only part of the wild ecotypes collected in various natural habitats of Lithuania are characterised by a diversity of morphological characteristics and agronomically valuable properties within the species. Some of the wild ecotypes were promising for breeding purposes.

2. A small portion (about 1.5%) of wild ecotypes, of smooth-stalked meadow grass and red fescue were found to be promising for turf grass breeding according to a whole set of agromorphological characteristics.

3. On the basis of the most promising wild ecotypes, the following turf grass varieties have been bred and registered in Lithuania: smooth-stalked meadow grass varieties 'Klotė' and 'Galvė' and red fescue 'Gludas'.

4. Wild ecotypes of timothy and meadow fescue were generally found to be insufficiently luxuriant for the development of forage-type varieties.

5. Part (about 3%) of forage-type plants were distinguished for foliar disease resistance.

6. On the basis of selection of wild ecotypes, four forage type varieties have been developed: smooth-stalked meadow grass 'Gaja' and 'Danė', redtop 'Violeta', reed canary grass 'Pievys'. The variety 'Pievys' can be used as a biomass producer, too.

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LAUKINIŲ EKOTIPŲ ATRANKOS EFEKTYVUMAS DAUGIAMEČIŲ ŽOLIŲ SELEKCIJAI

Santrauka

1995–2007 m. daugiamečių varpinių žolių genetinių kolekcijų tyrimų duomenimis, laukinių ekotipų atranka buvo efektyvi kuriant pašarinio tipo pievinių miglių, nendrinių dryžučių ir didžiųjų smilgų veisles. Geriausių laukinių ekotipų atrankos pagrindu sukurtos keturios veislės: pievinių miglių 'Gaja' ir 'Danė', didžiųjų smilgų 'Violeta' bei nendrinių dryžučių 'Pievys'. Tikrųjų eraičinų bei pašarinių motiejukų laukiniai ekotipai tiesiogiai veislių kūrimui netiko, nes buvo nepakankamai produktyvūs. Apie 3% tirtų varpinių žolių laukinių ekotipų buvo atsparūs lapų ligoms. Tiriant įvairių varpinių žolių rūšių genetines kolekcijas nustatyta, kad tiktai nedidelė dalis, apie 1,5%, laukinių ekotipų buvo perspektyvūs kuriant veisles vejoms. Iš geriausių pievinių miglių ir raudonųjų eraičinų laukinių ekotipų sukurtos trys vejų įrengimui tinkančios veislės – tai pievinių miglių veislės 'Klotė' ir 'Galvė' bei raudonojo eraičino veislė 'Gludas'.