Euphytica 77: 175–181, 1994.

Collecting and evaluating genetic resources of fodder plants from subalpine and alpine permanent grassland

U. Simon
Technical University Munich, Chair of Grassland and Forage Production, 85350 Freising-Weihenstephan, Germany

Key words: Alpine, fodder plants, genetic resources

Summary

The permanent grassland in the northern alpine and prealpine regions of Germany, Austria and Switzerland is characterized by a large genetic diversity of commercially important grass and clover species. This gene pool is endangered by the increasing practice of grassland renovation. The collection of genetic resources from that marginal habitat serves two purposes, therefore: Utilization of the gene pool in breeding programmes, and conserving the natural variation of endangered habitats. A considerable number of ecotypes of various species has been collected by several workers over a period of thirty years.

Special attention is given to the materials collected and evaluated by Scheller (several species), Tyler (several species), Spatz (perennial ryegrass), Krings & Simon (Italian ryegrass) and Simon (several species). The materials described contain genotypes which appear useful for the improvement of such agronomically important characters as date of heading, plant height, winter hardiness, persistency and rust resistance under marginal conditions. From Simon's collections six cultivars registered or applied for registration in the German List of Cultivars emerged.

Introduction

It is generally accepted that the availability of appropriate basic genetic materials is an indispensable prerequisite for any plant breeding programme aiming at the creation of improved cultivars (Simon, 1983; Tyler, 1987). Sources of such basic material may be existing cultivars, or the results of genetic manipulation such as crossing, inbreeding, induction of mutants and polyploids, genetic engineering and gene banks.

Many of the commercially important species which are useful for both fodder and non fodder purposes are integrated parts of the permanent grassland vegetation throughout Europe. It represents an excellent source of useful initial genetic breeding stock. It is quite logical, therefore, that this genetic potential is used extensively by plant breeders. The International Board for Plant Genetic Resources (IBPGR) established a Working Group on Forages, and the Report of this group (IBPGR, 1989) lists a considerable number of collecting activities for various species throughout Europe. Chorlton (1991) gives an account on the collection of genetic resources in the United Kingdom over the last thirty years.

In the northern alpine and prealpine regions of Germany, Austria and Switzerland permanent grassland covers from 50% up to 100% of the agricultural area. The botanical composition of this grassland is very variable depending on the prevailing climatic and soil conditions, and on the type and intensity of management.

From the great diversity of external factors and due to natural selection a large genetic diversity within species has emerged. Grasslands ranging from elevations of about 400 m a.s.l. to approximately 1000 m a.s.l. include important grass species such as perennial and Italian ryegrass, fescue (meadow tall, red, sheeps), Kentucky bluegrass, orchardgrass, timothy, and bentgrass species. Among the legumes naturally occurring in this area are white clover, wild red clover, alsike clover, and birdsfoot trefoil. The habitats of some special purpose species like *Poa supina, Festuca violacea*, and *Festuca apennina* extend even above 1000 m a.s.l.

Table 2. Classification of 'Spitalhof' ecotypes of perennial ryegrass according to date of heading; n = 359. Spatz, 1987

Days after April 1	42	49	52	56	63	70
Proportion of plants %	11	48	$\bar{x}$	33	4	4

Table 3. Relative dry matter yield of the 'Spitalhof' perennial ryegrass population

Year	Average 3 check varieties	Relative dry matter yield 'Spitalhof' population at		$\bar{x}$
		Spitalhof	Weihenstephan	
1985	100	112	123	117
1986	100	114	110	112
$\bar{x}$	100	113	117	115

Collection Spatz

The pastures of the grassland and livestock experiment station Spitalhof near Kempten (730 m a.s.l.) are dominated by an unusually high proportion of perennial ryegrass. Since commercially available cultivars lack sufficient persistency at this location, the indigeneous perennial ryegrass seemed to be superior in this respect. Spatz collected 359 plants from the habitat and in addition, harvested by combine a perennial ryegrass dominant pasture at the stage of seed maturity in 1983. The plants exhibited a large variation with respect to the date of heading (Table 2). The range extends over a period of 28 days, which covers almost the range of the 69 forage cultivars of perennial ryegrass (30 days) described in the 'Beschreibende Sortenliste Gräser, Klee, Luzerne' (Bundessortenamt, 1991). The average date of heading of the population, 52 days after April 1, coincides with the Bundessortenamt classification 'very early to early' (Bundessortenamt, 1991).

The combine harvested seed was used for the establishment of variety tests at the site of collection, Spitalhof, and in Weihenstephan. The 'Spitalhof' population exceeded the three check varieties in dry matter production at both locations (Table 3 -, Spatz et al., 1987).

Collection Tyler

B.F. Tyler of the Welsh Plant Breeding Station Aberystwyth collected ecotypes within our area in 1986. The number of accessions was: Perennial ryegrass 65, tall fescue 35, and 5 each of meadow fescue and giant fescue. This material was included in the WPBS collection for regeneration and further evaluation at WPBS and Weihenstephan. No detailed information about the results is available up to now.

Table 4. Italian ryegrass ecotype collection

Region	Altitude range m	Number of habitats 1990	1991	total
Germany				
– Oberbayern	382–815	53	9	62
– Niederbayern	400–640	10	–	10
– Schwaben	600–860	16	8	24
Switzerland	400–820	19	–	19
Total	382–860	98	17	115

Collection Krings and Simon

Italian ryegrass is the most productive forage grass within a crop rotation in Germany. Most of the commercially available cultivars have been developed in sea-coast adjacent countries such as Belgium, the Netherlands, Denmark, and northern Germany. Consequently, they are adapted to a relatively mild climate. Disappointing results have often been obtained when this grass was grown in the relatively rough climate of southern Germany due to its limited winter hardiness and short life time. On the other hand it is known that ecotypes of Italian ryegrass are prevalent in some of the south German permanent grassland which has never been sown. We assumed that among these ecotypes individuals can be found which exceed the presently available cultivars in winter hardiness, persistency, and perhaps other agronomically important characters. For this reason the Association for the Promotion of the Private German Plant Breeding (GFP) supported a collection and evaluation programme which we conducted from 1990 to 1993.

Five individual plants were collected from each of 115 habitats, 19 of which are located in Switzerland around Zurich (Table 4). Only the 1990 accessions will be considered within the scope of this report.

Each collected plant was cloned into 25 parts. 20 clone plants were used to establish a polycross nursery to produce seed for progeny tests. Each polycross consisted of the 5 clones of one habitat. The remaining

Table 7. Rust resistance of ecotype progenies at two locations 1992; 1 = very susceptible; 9 = very resistant

Location	Check		Ecotypes		
	Lemtal (d)	Lipo (t)	min.	mean	max.
Hohenlieth (45 m)	4.8	6.1	1.8	4.3	6.2
Grünschwaige (435 m)	5.3	6.5	1.6	3.7	6.4

Table 8. Winter hardiness of ecotype progenies at three locations 1992/93; 1 = very poor; 9 = very good

Location	Check		Ecotypes		
	Lemtal (d)	Lipo (t)	min.	mean	max.
Hohenlieth (45 m)	4.8	5.3	2.0	5.7	7.0
Grünschwaige (435 m)	1.6	1.4	1.0	2.0	5.0
Gereute (1085 m)	1.1	1.4	0.5	1.4	2.6

Table 9. Persistency of ecotype progenies at two locations 1992; 1 = very poor; 9 = very good

Location	Check		Ecotypes		
	Lemtal (d)	Lipo (t)	min.	mean	max.
Hohenlieth (45 m)	2.8	2.7	1.2	2.2	7.0
Grünschwaige (435 m)	2.8	2.7	1.7	3.6	7.6

Table 10. Species and number of ecotypes collected by Simon 1963 to 1993

Species	Number	Species	Number
Agrostis stolonifera	13	*Lolium perenne*	87
Dactylis glomerata	20	+ seed ≈ 3000 plants	
Festuca apennina	5	*Phleum bertolonii*	23
Festuca pratensis	9	*Phleum pratense*	6
Festuca violacea	14	*Poa supina*	133
		Trifolium pratense	14

Winter hardiness. Data for winterhardiness are presented in Table 8. Obviously, the winter stress increases with increasing altitude of the testing sites. The duration of snow cover in the winter 1992/93, for instance, was 43 days in Hohenlieth (45 m), but 143 days in Gereute (1085 m). The important fact, however, is that the average winter hardiness of the ecotype progenies is superior to that of the check varieties. This is particularly true at the testing sites Grünschwaige (435 m) and Gereute (1085 m). We feel that the collected ecotypes include very valuable genetic resources for improving winter hardiness in Italian ryegrass.

Persistency. Italian ryegrass is less persistent than perennial ryegrass. To improve the persistency of Italian ryegrass is not only an important breeding aim in the highlands but in the lowlands as well. Persistency in this investigation is expressed in terms of general appearance in the autumn 1992. The relevant data of one lowland (Hohenlieth 45 m) and one highland (Grünschwaige 435 m) testing site are presented in Table 9. It is very obvious that the progenies include ecotypes that are much more persistent than the check varieties. This is particularly true at Grünschwaige where persistency is greater than at Hohenlieth. Over 75% of the tested progenies exceed the best check variety in persistency here. In conclusion, the collected ecotypes include valuable genetic resources for improving both winter hardiness and persistency of Italian ryegrass particularly under highland conditions.

Collection Simon

Simons collection of ecotypes is summarized in Table 10. Comments are made on only a few of the mentioned species.

Agrostis stolonifera. This stoloniferous grass forms a very fine and dense turf when cut frequently very close to the ground. 'Schönbrunn' is one accession which compares favourable with the Dutch cultivar 'Prominent'. The application for registration in the German List of Cultivars is pending.

Festuca violacea. Festuca violacea is an alpine grass growing between 1600 and 2500 m a.s.l. (Oberdorfer, 1990). This species has not been included in a breeding programme to the authors knowledge. It may have a potential for special purposes like seedings on ski tracks and avalanche prone sites in high altitudes. It is also useful as a forage grass. Our material has been

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