Morphological variation in Dutch perennial ryegrass (Lolium perenne L.) populations, in relation to environmental factors

B.P. Loos *
Centre for Plant Breeding and Reproduction Research (CPRO-DLO), P.O. Box 16, 6700 AA Wageningen, The Netherlands

Received 18 August 1993; accepted 6 December 1993

Key words: Lolium perenne L., morphologic variation, geographic differentiation, environmental factors, subsampling of locations

Summary

Twenty-one Dutch Lolium perenne populations, fifteen European populations and six L. perenne cultivars were compared for morphological variation. Dutch populations clearly differed from the European populations and the cultivars. Dutch populations generally had reduced plant length and smaller leaves. For other characters, e.g. date of ear emergence, the Dutch populations showed as much variation as the European populations and cultivars they were compared with in this trial. Correlations between morphology and environmental factors at the site of origin were significant in several cases but were generally weak, and dependent on the set of populations studied. In order to maximize the phenotypic differences between the collected populations, soil type and management type appeared to be the most important factors for the choice of collection sites in the Netherlands. To determine suitable collection sites all over Europe, other factors like precipitation, latitude, altitude and temperature factors were also important. For subsampling of the locations, variation in management type within the location determined whether or not phenotypic different samples could be collected. The extensive use of cultivars in the Netherlands does not seem to have prevented the formation of distinct populations. Therefore in situ conservation of grassland seems a good alternative for genetic conservation of L. perenne in the Netherlands.

Introduction

Although Lolium perenne L. (perennial ryegrass) has been known for centuries as a fodder species, its agronomical importance increased significantly during the last century. In the Netherlands, about 150,000 ha of grassland is annually seeded or reseeded (Rassenlijst, 1993) on a total of about one million ha of grassland. The percentage of L. perenne seeds in the used seed mixtures has increased from about 45% in the period of 1953–1965 to 84% in 1991/92. The tonnage of seed mixtures used also increased during this period.

The first breeding activities already took place in the 18th century in England by a.o. Pacey (Beddows, 1953). The first ryegrass cultivars appeared on the Dutch variety list in 1927, all seed stocks being derived from foreign material. In 1934 the first cultivars based on Dutch material were listed: ‘Ceres’ and ‘Brabantia’. Extensive breeding programmes were started after 1940 in the Netherlands, at first concentrating on the development of good fodder types (Vos, 1983). Later this century, cultivars were developed for more diverse purposes. This resulted in the separate listing of cultivars adapted for different applications, e.g. lawns and sportfields, since 1974 on the Dutch variety list.

Increasing economic importance also resulted in increased collecting of L. perenne populations. These collections were stored in genebanks or used in breeding programmes. These populations are of great importance to perennial ryegrass breeding. In the early days of perennial ryegrass breeding collected plants

* Also associated with the WAU Department of Plant Taxonomy, P.O. Box 8010, 6700 ED, Wageningen, The Netherlands
or seeds from several areas were combined, multiplied and exposed to mild selection pressure, to compose a new cultivar. Although breeding methods have become more advanced, it is assumed that breeding success still largely depends on the quality of the basic breeding material. In the past Dutch cultivars were largely obtained using collections of Dutch material, but during the last ten years the use of Dutch populations has decreased. Due to the widespread practice of (re)seeding and the intensive sampling of grassland in the Netherlands in the past, the assumption was made that no genetically new material could be collected in the Netherlands (Glas, 1983). Aim of the present study is to assess the genetic variation of Dutch populations and to compare these to European populations and cultivars to determine whether Dutch populations constitute a valuable part of the genetic resources of L. perenne in Europe.

The success of subsampling of the Dutch locations is determined. Tyler and Chorlton (1976) state that on very small areas large differences in phenotype can be found, suggesting that intensive sampling of variable locations can result in genotypically different samples.

Material and methods

Plant material

In October 1990 twenty-one L. perenne populations were sampled from seven locations in the Netherlands. Selection criteria for the locations were: the grassland had not been seeded or reseeded for at least fifteen years, the location had been managed either by grazing, haying or a combination of both, and the locations comprised an area of at least 30 ha. The locations were selected by using the information provided by Provincial Landscape Organisations, owning and managing the grassland. On each location three populations were collected consisting of 60 plants each. To avoid duplicate sampling, plants were collected at least 0.5 meters apart. The sites within each location were spaced about 100–300 m. Each site was chosen to represent a contrast within the location (e.g. path versus wetland).

Besides the Dutch populations, fourteen populations from the European Forages database (Tyler, 1989) were selected and obtained through the Welsh Plant Breeding Station. These populations were selected on basis of their country of origin and their classification as semi-cultivated. Additionally one Austrian ecotype was obtained from Mr. Klein-Geltink (CPRO-DLO).

Besides the populations, six L. perenne cultivars were chosen, which had been on the Dutch variety list for over thirty years. These varieties have been used extensively over the years and most of them are based on Dutch populations, thus representing a part of the variation of Dutch populations. Detailed information on all populations is given in Table 1.

Field design

The European populations and the cultivars were sown mid September 1990, and transplanted to the field at the end of October. The plants of the Dutch populations were planted in pots (18 by 18 cm) and kept outdoors during winter. In the beginning of March 1991 these plants were transplanted to the field. All plants were cut at 15 cm height. Each population consisted of 60 plants, layed out in the field in a complete randomized block design, with three blocks containing plots of twenty plants each. In the spring of 1991 the characters (Table 2) were measured on each plant. After the measurements all plants were cut back, this was repeated twice in 1991 and at the beginning of March 1992. In spring 1992, measurements were repeated (Table 2). One character was added: habitus, which was scored on March 25, 1992.

Data analysis

As the layout of the experimental field was identical in both years the heritability could be calculated for the characters observed in both years, using the average per plot for each character:

\[
\begin{array}{ccc}
\text{Df} & \text{MS} & \text{E(MS)} \\
\text{Replication} & r-1 & \\
\text{Year} & y-1 & \\
\text{Genotype} & g-1 & MS_g \sigma_e^2 + ry \sigma_g^2 + r \sigma_{gy}^2 \\
\times \text{year} & (g-1)(y-1) & MS_{gy} \sigma_e^2 + r \sigma_{gy}^2 \\
\text{Error} & (r-1)(gy-1) & MS_e \sigma_e^2 \\
\end{array}
\]

Df = degrees of freedom, MS = mean square, E(MS) = expected mean square