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VARIATION OF EUROPEAN ECOTYPES OF PERENNIAL RYEGRASS (*LOLIUM PERENNE* L.)

ABSTRACT

The creation of new perennial ryegrass varieties is impossible without instant access to wide range of natural variation i.e. to the ecotypes originating from different regions. The main goal of described experiment was to compare number of morphological, phenological and useful traits of European core collection of perennial ryegrass ecotypes in climatic conditions of Poland. Total number of 156 objects (incl. 4 standard varieties) originated from different regions of Europe were exposed to two management regimes (conservation and frequent cutting). During three subsequent years 22 qualitative and quantitative traits described variation of 'main collection'. Further, on the basis of cluster analysis 'sub-collection' of 28 ecotypes from 9 clusters was selected and evaluated for 71 traits in field in similar management regimes as 'main collection'.

On the basis of ecotypes variation described it is possible to indicate following regions of ecotype origin in Europe: South Europe, West Europe, North-Middle Europe and Romania and Hungary. None of tested ecotypes exposed better yield formation than control varieties, however few ecotypes appeared to have better particular traits (better winter performance, faster spring regrowth etc.). Traits associated with inflorescence morphology (distance between florets in spikelet and distance between spikelets in spike, length of spikelet) seems to be the most stable traits, as contrary to abundance of inflorescences, tendency to produce inflorescences in year of sowing and green matter yield of first cut. High differentiation of ecotypes examined indicate existence of many botanical varieties as well as ecotypes of transition nature.

Key words: perennial ryegrass, core collection, variability of ecotypes

INTRODUCTION

Germplasm is one of man's most valuable natural resources as an element of natural diversity (Burton 1979). The practical use of genetic resources as an aid to development of existing varieties can only be achieved through wise management of genetic diversity. It is well known that during germplasm storage some damage to genetic information may occur (Breese 1989a, b). Stored accessions should be therefore regenerated but in large collections it could be a great problem. Recognising that the size of germplasm collection could deter its use, it was proposed that it could be pruned to a 'core collection' (Brown 1995, after Frankel 1984). The core collection would represent 'with minimum repetitiveness, the genetic diversity of a crop species and its relatives'.

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In view of above problems a core collection strategy was proposed during meetings of ECP/GR Forage Working Group in 1991 and 1994 and it was decided to develop European core collection for perennial ryegrass (*Lolium perenne* L.) ecotypes (IPGRI 1992, Gass *et al.* 1995).

Perennial ryegrass originated from Mediterranean region and west Asia and is distributed throughout Europe to Northern Scandinavia and in parts of Asia and North Africa (Balfourier *et al.* 2001, Bennett 1997). It is one of the major grass species in Europe and is widely bred and cultivated as a forage, turf or soil-binding grass (Góral and Góral 1981, Meyer and Funk 1989, Mitchley *et al.* 1996). Despite of its high quality, perennial ryegrass is rather susceptible for low temperature, summer syndrome effect (drought and heath) and diseases (Jurek 1987, Wilkins 1991, Prończuk and Prończuk 1993).

The creation of new perennial ryegrass varieties is impossible without instant access to wide range of natural variation i.e. to the ecotypes originating from different regions. In view of literature published hitherto, in Poland there were no experiments carried on perennial ryegrass ecotypes collected from different regions of Europe. Some studies were made only on Polish ecotypes (Osiński 1979, Jargiełło and Mosek 1988, Jargiełło and Sawicki 1991, Sawicki and Jargiełło 1994, Martyniak and Żyłka 1997, Żurek and Prończuk 1997, Sawicki 1999).

The Perennial Ryegrass Core Collection was developed in 17 European countries, holding ryegrass collections. One hundred and fifty four ecotypes with 4 control varieties (‘main’ core collection) were planted, cultivated and evaluated according to methodology given by Sackville Hamilton *et al.* (1997) and Marum *et al.* (1998).

The principal goal for core collection evaluation in Bydgoszcz was to examine variation of European ryegrass ecotypes in conditions of Poland, with wider range of traits than accepted for ‘main’ core collection.

MATERIALS AND METHODOLOGY

‘Main’ core collection

Seed accessions of 152 accessions were provided by curators of *Lolium perenne* collections from 17 European countries. In the spring of 1995 seeds of ecotypes, together with control varieties (Arion, Frances, Talbot and Vigor) were sown to receive seedlings that were further planted into small pots and grown from March to June in cold greenhouse. In July young plants were planted in the filed in 4 replicates, in 1,5 m long rows with seven plants at 25 cm intervals and 75 cm between the rows in split-plot design. Two replicates were subjected to conservation management, with a cut when the last accession has 50% anthesis. Other two replicates were subjected to frequent cutting management (simulation of periodic grazing) with cuts every 3 -5 weeks, as appropriate for the evaluation site.

The evaluation protocol was based on IBPGR descriptor list (Sackville Hamilton *et al.* 1997, Marum *et al.* 1998). Following scores were observed:

heading tendency	—	tendency to produce inflorescences in year of sowing (in scale 1 = none to 9 = high),
winter damage	—	estimated % of dead tillers (in scale 1 = minimum to 9 = maximum),
heading date	—	no. of days form 1st of April to inflorescence emergence,
plant habit	—	tiller angle (in scale 1 = horizontal/prostrate to 9 = vertical/erect),
leaf blade width at heading	—	(in scale 1 = very narrow to 9 = very wide),

Cuts in conservation management were adjusted to the development phase (i.e. earliness) and were made 5 times per first cut (28.05.96, 03.06.96, 21.06.96, 25.06.96, 01.07.96), one time per second cut (01.09.96) and one time per third cut (15.10.96). Estimation of yield in frequent cutting management were made 6 times ca. one month from 15.05.96.

Winter 1996/1997 damages affected majority of above collection so strongly that further evaluation would be ineffective. It was than decided to redefine above core collection on the basis of results from 1995 and 1996 and to provide precise evaluation on so-called ‘sub-collection’. Cluster analysis (UPGA and Euclidean distance) was performed on 22 characters and sub-collection of 28 ecotypes from 9 clusters was selected. Such methodology of selection of sub-samples for further analysis was similar to Charmet *et al.* (1990) and Casler (1995).

Sub-collection

Control varieties were the same as in ‘main’ core collection and two Polish varieties were added: Nadmorski and Arka.

Seed from selected accessions were sown in August of 1997, and young seedlings were planted into pots in the hot-bed, and planted in the field at the end of September of 1997. Six replications were used (3 replications in frequent cut and 3 replications in conservati on management) with 10 plants per replication. Evaluation and measurements were performed in 1998 - 1999.

Apart from traits similar to ‘main’ collection additional evaluation were done on:

young seedlings in pots	—	no. of leaves (4 weeks after planting in pots), no. of tillers and seedling dry matter weight [grams per seedling] (8 weeks after planting) and average dry matter of tiller [total plant dry matter weight / no. of tillers],
plants in the field	—	abundance of inflorescences at frequent cut, plant height and length of steam leaf at the beginning of heading in conservation management,

dry plants (cut at the heading phase)	— for three longest stems per plant following traits were measured: height, length of inflorescence, no. of spikelets per inflorescence, no. of florets per spikelet, length of spikelet (mm), intensity of spike branching (in 1-9 scale were 1 is no branching, 3 - branching only on a few stems, 5 - branching on some spikes, 7 - numerous branching on few stems, 9 - very numerous branches on numerous stems), distance between florets in spikelet and distance between spikelets in spike, no. of main stem branches,

Analysis of variance on 71 characters (one-way ANOVA) was performed. To describe variation of selected ecotypes in different conditions results from 'main' core collection were compared to results from sub-collection. For sub-collection results, Person correlation coefficients (r) were calculated for the same traits evaluated in different years. If r was high (more than 0.6) mean value from both years were accepted for further calculations. Further, principal component analysis (PCA) with varimax rotation and cluster analysis (UPGA and Euclidean distance) were performed.

RESULTS

'Main' core collection

For ecotypes from 'main' core collection analysed on the basis of country of origin differentiation for all 20 traits were significant for ecotypes from: France, Great Britain and Switzerland. The lowest trait differentiation was observed for ecotypes form Czech Republic (4 traits), Bulgaria (6) and Greece (7).

Cluster analysis selected 9 groups of ecotypes. Clusters were characterised as follows (Table 1):

1st cluster	— the earliest ecotypes, with high percentage of heading in sowing year and with high abundance of inflorescences, high rust infestation after the second cut;
2nd cluster	— a no heading in the sowing year, low winter damage and good yielding, the highest value of abundance of inflorescences at the second cut;
3rd cluster	— early heading, the narrowest leaves and prostrate habit;
4th cluster	— high green matter yield estimated in first cut in frequent cutting management, no heading in a sowing year, high rust infestation of the third regrowth, good yields especially at spring cuts;
5th cluster	— low percentage of heading in a sowing year and at the second and third regrowth, good yields of autumn cuts;

6th cluster	—	low winter damage and good yields, wide leaves and erect habit;
7rd cluster	—	good yields, the latest ecotypes with low percentage of heading in a sowing year;
8th cluster	—	the highest values of winter damage and the lowest yields, prostrate habit and the highest percentage of heading in a sowing year;
9th cluster	—	no heading in a sowing year, rather late, prostrate habit, high rust infestation of the third cut.

Table 1

Cluster characteristic of ecotypes from European core collection of perennial ryegrass

Trait	Cluster number								
	1	2	3	4	5	6	7	8	9
Tend. to produce infloresc. in sowing year 1995[(%]	0.35	0.00	0.48	0.00	0.03	0.00	0.00	0.95	0.00
Winter damage (scale)	5.8	4.5	6.4	3.7	5.9	4.3	4.9	8.1	6.1
Heading date (of days form 1st April)	52.9	60.1	56.4	62.0	63.8	63.6	69.1	63.7	66.8
Plant habit (scale)	5.5	5.4	3.7	4.2	4.6	6.8	4.6	3.9	3.6
Leaf blade width (scale)	5.0	5.1	4.5	5.1	4.8	6.0	5.5	4.7	4.6
Bulks - 1st cut in conservation management (kg $\times m^{-2}$)	1.0	2.0	0.8	2.1	1.7	2.5	2.7	0.3	1.4
Bulks - 2nd cut in conservation management (kg $\times m^{-2}$)	1.7	1.9	1.2	2.0	1.9	2.1	2.1	0.8	1.5
Bulks - 3rd cut in conservation management (kg $\times m^{-2}$)	1.5	1.4	1.1	1.4	1.9	1.7	2.1	1.2	1.5
Total bulks - in conservation management (kg $\times m^{-2}$)*	4.2	5.3	3.2	5.5	5.4	6.4	6.9	2.3	4.5
Rust infestation at 2nd cut in conserv. manag. (scale)	5.6	5.2	5.2	5.4	4.3	4.7	4.1	4.1	4.7
Rust infestation at 3rd cut in conserv. manag. (scale)	6.1	5.9	5.8	6.2	5.7	5.8	5.7	4.3	6.2
Abund. of infloresc. at 2nd cut in conserv. manag. (scale)	6.5	7.4	6.6	7.2	3.7	5.2	2.8	6.7	3.7
Abund. of infloresc. at 3rd cut in conserv. manag. (scale)	2.4	3.1	3.3	2.4	1.3	2.2	1.4	4.5	1.4
Bulks - 1st cut in frequent cutting (scale)	3.6	4.5	2.8	4.8	3.6	4.5	4.3	1.5	2.9
Bulks - 2nd cut in frequent cutting (scale)	3.7	4.5	2.9	5.0	4.0	4.9	4.8	1.8	3.5
Bulks - 3rd cut in frequent cutting (scale)	3.5	3.8	2.4	4.3	3.7	4.2	4.6	2.0	3.4
Bulks - 4th cut in frequent cutting (scale)	3.6	4.0	2.7	4.5	4.0	4.3	4.8	2.0	3.9
Bulks - 5th cut in frequent cutting (scale)	3.8	3.7	2.8	4.0	4.3	4.1	5.1	2.3	3.8
Bulks - 6th cut in frequent cutting (scale)	4.0	3.4	2.7	3.2	3.9	3.6	4.4	2.8	2.9

As a result of cluster analysis on country mean values following groups were selected: first group - one element - Bulgaria (n=6); second group - Mediterranean countries (Italy, Spain and Greece, n=17); third group - one element - Switzerland (n=4); fourth group - rest of Europe (n=130). In the last group some subgroups also appeared: Czech and Poland; Germany, Belgium and Netherlands; Great Britain and France.

Sub-collection

As compared to control varieties, ecotypes from sub-collection showed higher values of coefficient of variation for: dry matter weight per stem, winter damages, fresh matter yield of the last conservation cut, yields in frequent cutting, abundance of inflorescences at: conservation management in 1996, third and fourth regrowth in frequent cut, rust infestation in 1996 and in frequent cutting in sub-collection, intensity of spike branching, plant habit, length of spikelet in 1998, average distance between florets in spikelet and width of leaves in 1996 and 1999.

Principal component analysis selected 5 components (Table 2). First component accounted for 19.3% of variation and was mostly related to vegetative development. It was negatively correlated with following traits: abundance of inflorescences at both treatments and number of florets in spikelet in 1999. Positive correlation was found for number of days to heading. Second component (yield ability) accounted for 22.4% of variation and was strongly positively correlated with: yields from both treatments (especially for first cuts), height of plants at heading, length of leaves and inflorescences. Negative correlation was found between second component and winter damages, especially in first year of experiment. Third component (rust infestation) accounted for 9.8% of total variation. Fourth component was correlated with width of leaves and length of spike, no. of florets in spikelet in 1998. Fifth component, accounting for 8.7% of variation, was highly correlated with seedling dry matter weight, average dry matter of tiller and winter damages in 1999.

Table 2

Principal component analysis for sub-collection of perennial ryegrass ecotypes

Traits iinvestigated	Factor number								
On young seedlings (pots 1997)	1	2	3	4	5	6	7	8	9
No. of leaves	0.11	-0.10	-0.25	0.01	0.28	0.80	0.08	-0.10	0.04
No. of tillers	0.12	-0.10	-0.11	-0.14	0.05	0.73	-0.31	-0.40	-0.07
Average dry matter of tiller	0.02	-0.11	0.02	0.06	0.83	0.32	0.00	-0.13	0.00
Seedling dry matter weight	-0.02	-0.15	0.13	0.15	0.81	-0.18	0.23	0.23	0.08
	Winter damage								
In year 1996	0.23	-0.70	0.28	-0.05	0.44	0.18	-0.15	0.03	-0.04
In year 1997 in conservation management	0.39	-0.52	0.12	-0.01	0.53	0.18	-0.07	-0.09	0.02
In year 1997 in frequent cutting	-0.01	-0.71	0.29	-0.11	0.39	0.19	0.12	0.07	-0.02
In year 1998	0.21	-0.82	0.25	-0.02	0.33	0.11	0.06	-0.07	0.10
In year 1999 in conservation management	0.33	-0.44	0.00	0.06	0.71	0.13	0.17	0.03	-0.14
In year 1999 in frequent cutting	0.29	-0.30	0.36	0.08	0.62	-0.04	-0.05	0.39	-0.12
In conservation management	Bulks								
1st cut*	0.27	0.85	0.07	0.19	-0.22	0.13	-0.08	0.05	-0.06
2nd cut in year 1998	0.14	0.86	0.01	-0.11	-0.11	0.04	0.00	0.00	-0.34
2nd cut in year 1999	-0.60	0.25	0.06	-0.32	-0.01	-0.33	0.27	-0.23	-0.03
3rd cut*	0.28	0.47	0.51	-0.16	0.28	0.08	0.04	-0.11	-0.32
sum cuts*	0.23	0.90	0.12	0.06	-0.14	0.09	-0.03	0.01	-0.17

Table 2

Principal component analysis for sub-collection of perennial ryegrass ecotypes (continued)

Traits investigated	Factor number								
	1	2	3	4	5	6	7	8	9
In frequent cutting	Bulks								
1st cut*	-0.26	0.80	-0.20	-0.01	-0.18	-0.10	-0.15	-0.24	0.16
2nd cut*	0.25	0.91	-0.10	0.05	-0.02	-0.08	-0.06	0.11	0.04
3rd cut*	0.22	0.90	0.08	-0.07	0.14	-0.13	0.04	0.08	0.09
4th cut*	0.23	0.61	0.39	-0.28	0.31	0.15	0.18	0.07	0.26
sum cuts*	0.15	0.92	-0.04	-0.02	0.09	-0.11	-0.03	0.12	0.07
In conservation management	Rust infestation								
2nd cut in year 1996	-0.59	0.05	-0.28	-0.23	-0.17	0.03	0.22	-0.21	0.32
2nd cut in year 1998	-0.25	-0.28	-0.75	-0.24	-0.12	0.09	0.05	-0.11	-0.09
2nd cut in year 1999	-0.54	-0.19	-0.52	-0.05	0.10	-0.39	0.02	-0.13	0.03
3rd cut in year 1996	0.01	0.35	-0.72	-0.24	-0.23	0.13	0.18	-0.03	0.13
3rd cut*	-0.19	0.12	-0.85	0.21	-0.18	0.08	-0.07	0.15	0.00
In frequent cutting	Rust infestation								
3rd cut in year 1998	0.42	0.26	-0.70	0.07	0.13	0.14	-0.29	-0.07	-0.07
3rd cut in year 1999	0.34	-0.12	-0.73	-0.21	0.18	0.19	0.04	-0.17	0.14
4th cut*	-0.02	0.46	-0.67	0.28	-0.09	-0.12	-0.09	0.03	-0.35
	Phenology								
Heading date in year 1996	0.71	0.23	0.29	0.26	-0.09	0.01	-0.07	0.27	-0.25
Heading date*	0.71	0.30	0.26	0.38	-0.10	0.06	-0.14	0.27	-0.01
In conservation management*	Abundance of inflorescences								
2nd cut in year1996	-0.87	-0.01	0.02	0.08	-0.23	0.03	0.02	-0.08	0.24
2nd cut*	-0.90	-0.15	0.02	-0.15	-0.18	-0.11	0.03	-0.08	-0.12
3rd cut in year 1996	-0.76	-0.18	0.18	0.37	-0.25	0.03	-0.06	0.09	0.17
3rd cut in year 1998	-0.83	-0.11	0.11	-0.13	-0.12	-0.08	0.05	-0.14	0.00
In frequent cutting	Abundance of inflorescences								
2nd cut*	-0.89	-0.26	-0.12	0.02	-0.03	-0.08	0.00	-0.08	0.01
3rd cut in year 1999	-0.81	0.03	0.23	0.16	-0.36	-0.04	-0.04	0.12	-0.20

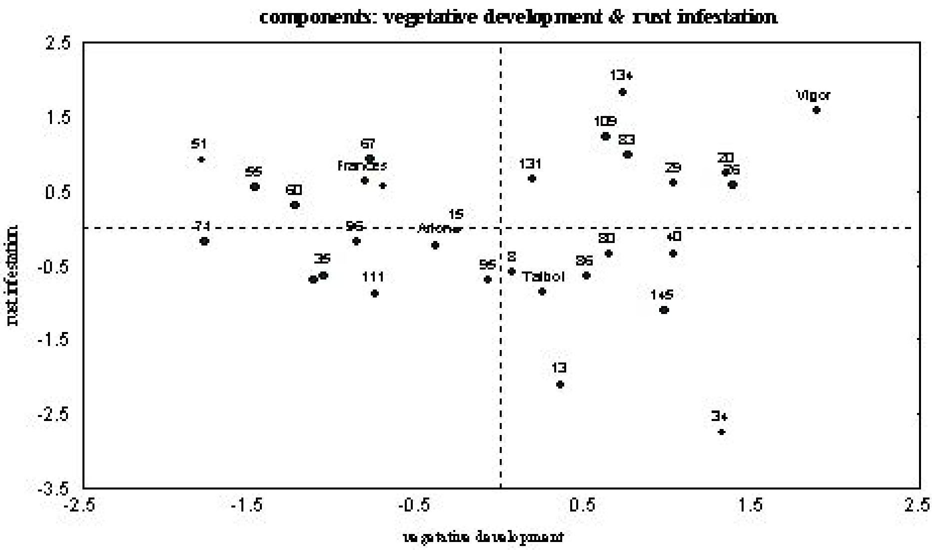
Table 2

Principal component analysis for sub-collection of perennial ryegrass ecotypes (continued)

Traits investigated	Factor number								
	1	2	3	4	5	6	7	8	9
	Morphological traits								
Plant height (beginning of heading in 1998)	0.52	0.47	-0.02	0.57	-0.04	0.15	-0.08	0.18	-0.01
Plant height (beginning of heading in 1999)	0.01	0.82	0.10	0.10	-0.08	0.30	0.19	-0.19	0.05
Height at the heading phase*	0.39	0.63	0.16	0.39	-0.24	0.32	-0.18	0.06	0.05
Length of steam leaf (beginning heading)*	0.41	0.69	-0.04	0.43	0.01	-0.04	-0.02	0.08	-0.06
Steam leaf blade width (beginning heading)*	0.32	0.00	-0.03	0.75	0.37	-0.13	0.08	0.22	0.03
Length of inflorescence*	0.26	0.59	0.21	0.61	-0.28	0.01	-0.06	0.06	-0.03
Length of spikelet*	-0.29	-0.04	0.01	0.84	0.20	-0.01	0.08	-0.22	0.04
No. of spikelets per inflorescence *	0.37	0.54	0.06	0.43	-0.25	-0.12	-0.15	0.46	-0.02
Distance between spikelets in spike*	-0.35	-0.19	0.10	0.12	0.05	0.19	0.22	-0.74	-0.06
No. of florets per spikelet in year 1998	0.02	0.20	-0.01	0.70	-0.04	0.00	-0.58	0.12	-0.11
No. of florets per spikelet in year 1999	-0.82	-0.11	-0.13	0.20	0.34	0.07	0.04	-0.04	-0.09
Distance between florets in spikelet u in 1998	-0.03	-0.22	0.19	-0.14	0.06	-0.11	0.78	-0.12	0.20
Distance between florets in spikelet in 1999	0.70	0.01	0.11	0.26	-0.04	-0.04	0.37	-0.30	0.21
Intensity of spike branching in year 1998	0.14	-0.20	0.18	0.33	0.14	-0.22	-0.12	0.76	0.05
Intensity of spike branching in year 1999	0.02	0.11	0.03	-0.15	0.35	0.08	0.32	0.58	-0.39
Branches of main stem in year 1998	0.56	0.28	0.36	-0.01	0.00	0.30	-0.33	0.16	0.27
Plant habit*	-0.12	0.18	-0.16	0.08	0.19	0.00	0.76	0.01	-0.26
Eigen value	10.21	11.85	5.18	4.39	4.59	2.37	2.64	2.92	1.30
Total variation explained [%]	19.3	22.4	9.8	8.3	8.7	4.5	5.0	5.5	2.5

* Mean value from year 1998 to 1999

When plotting them over first and second and first and third components (Fig. 1) it is visible that: ecotypes no. 26 and 29 from Belgium, ecotypes no. 83 from the Netherlands and 134 from Switzerland were of low rust infestation, high yield ability and low ability to produce flowering stems (high vegetative development). The highest yield ability were noted for ecotype 51 from Hungary, and the lowest yielding - for ecotype 67 from Spain. Variety Vigor exposed the lowest ability to produce flowering stems (the highest vegetative development) as contrary to ecotypes from Spain and Hungary (ecotypes: 71 and 55, respectively). Ecotype from Switzerland (134) were of the lower rust infestation as contrary to ecotype 34 from Sweden. Except Vigor, variation of all ecotypes in sub-collection were wider than control varieties.



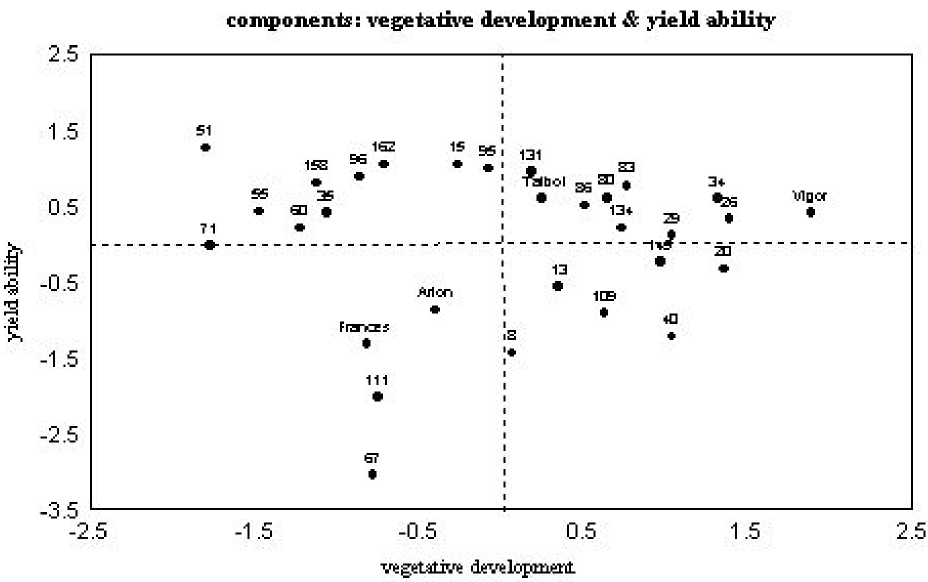


Fig. 1. Principal component analysis - sub-collection. Explanation: numbers and names near dots on graphs - no. of ecotypes and names of varieties

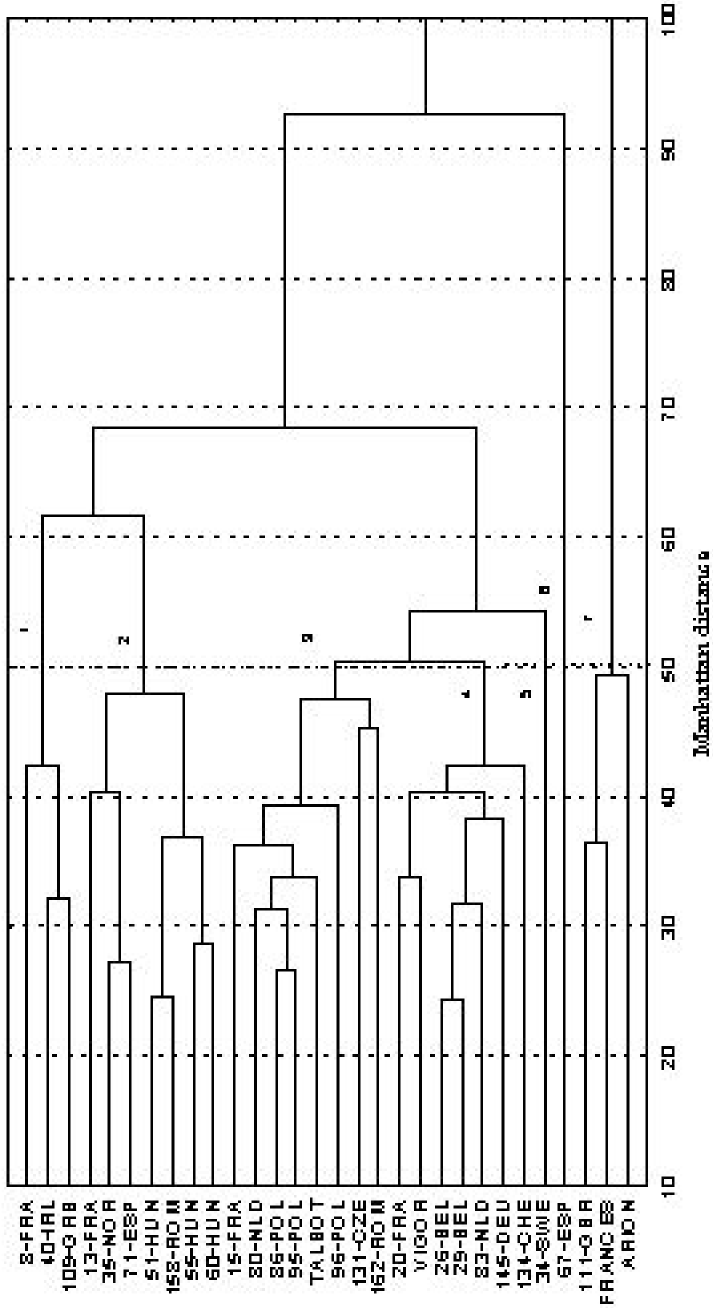


Fig. 2. Results of cluster analysis - sub-collection. Explanation: numbers inside graph (1-7) - no. of clusters

Table 3

Cluster characteristic of sub-collection of perennial ryegrass ecotypes

Traits	Cluster number / Number of ecotypes						
	1 / 3	2 / 7	3 / 8	4 / 7	5 / 1	6 /1	7 / 3
Average dry matter of tiller [mg]	219.7	207.9	216.1	233.0	146.0	213.0	243.0
Seedling dry matter weight [mg per plant]	13.4	13.4	15.1	14.9	14.8	21.0	17.2
Winter damage in year 1998 [scale]	7.3	4.1	3.9	5.8	3.4	8.8	7.2
Total bulks in conserv. manag.* [kg×m^{-2}]	1.91	2.60	3.27	3.01	2.83	0.27	1.27
Spring bulks - first cat 1 in frequent cut* [kg×m^{-2}]	0.27	0.80	0.74	0.53	0.64	0.05	0.36
Sum bulks in frequent cut* [kg×m^{-2}]	1.46	2.71	3.43	2.83	3.58	0.21	1.34
Rust infestation in 3rd cut in frequent cut* [scale]	6.0	6.6	6.5	5.9	7.7	6.3	6.1
Heading date* [days from 1st April]	59.0	51.9	59.3	65.8	65.0	58.9	43.1
Infloresc.abund. (2nd cut in conserv. manag.)* [scale]	4.1	6.2	4.4	2.2	1.6	5.9	6.2
Height at the heading phase* [cm]	50.3	57.2	62.2	67.7	60.9	48.2	40.6
Steam leaf length (beginning heading)* [cm]	18.6	19.3	22.4	21.7	24.2	17.4	16.4
Steam leaf blade width (beginning heading)* [mm]	6.2	6.0	6.4	6.4	7.2	7.3	5.7
Length of spike* [cm]	19.7	22.1	22.9	23.7	24.6	21.8	16.9
No. of spikelets per inflorescence *	20.8	21.4	24.0	24.1	28.5	23.8	15.4
Distance between spikelets in spike* [mm]	9.60	10.43	9.74	9.92	8.77	9.40	11.1
Plant habit [scale]	4.2	4.4	4.7	4.4	5.9	3.6	5.1

* Mean value from year 1998 to 1999

For 7 clusters shown on the Fig. 2 mean values for selected traits were calculated. Ecotypes in clusters were characterised as follows (Table 3):

1st cluster — (ecotypes from Western Europe). low yield ability, high winter damages and low dry matter of seedlings;

2nd cluster — (ecotypes from Hungary and one from Romania, Norway and France). Low dry matter yield of seedling, low winter damage, high yield ability, the highest yield of fresh matter in early spring cut, high tendency to abundance of inflorescences at second regrowth;

3rd cluster — (variety Talbot, ecotypes from: Poland (3) and one from France, Netherlands, the Czech Republic and Romania). High yield ability and low winter damage;

4th cluster — (variety Vigor, ecotypes from Belgium (2) and one from France, Netherlands and Germany). High dry matter yield of seedlings, good yielding, late heading and the highest plant at heading;

5th cluster — (an ecotype - 34. from Sweden) - high yield ability in frequent cut management, wide and long leaves, the highest number of florets per spikelet, high intensity of spike branching and low dry matter of seedlings, 4th cluster — an ecotype - 67 from Spain). High yield ability in frequent cut management, very low plants during heading, short and wide leaves,

5th cluster — (varieties Arion and Frances, and an ecotype 111. from Great Britain). Very early heading, high winter damages, high abundance of inflorescences at the second cut, short and narrow leaves, short inflorescence, low intensity of spike branching and high seedling dry matter.

DISCUSSION AND CONCLUSIONS

Winter damages affected all characters examined. Observations taken on perennial ryegrass core collection winter damages in Norway and Czech Republic gave similar results (Sackville-Hamilton *et al.* 1997). Different reaction was observed in Great Britain and Germany where practically no winter damages were observed and even winter yield was measured. As contrary, the lowest ratings were assigned to ecotypes that exposed low winter damages in Czech Republic and Norway. Range of winter damages is therefore close related to the origin of ecotype with highest values in region closest to place where the ecotype was originally collected.

The differentiation of winter damages estimated in the second year was lower for conservation management (higher mean value of trait) than for frequent cutting. It could be due to weaker condition of plants resulting from cuts made in later phases than in frequent management.

Analysis taken on yields indicated that ecotypes from north-east and east Europe (especially from Romania) were of higher yield potential in spring cuts. Similar results were obtained for Romanian ecotypes by Tyler *et al.* (1984) and Charmet and Balfourier (1991). Differences in yield were observed for different cuts and management. But, as it has been said before, winter damages affected them mostly. High, negative correlation was calculated between first cuts and winter damages for 'main' core collection (Schmidt and Kaszuba 1997). However, decreasing value of correlation coefficient in later cuts could be the effect of high regeneration ability of ecotypes.

Observation taken by Sadowski *et al.* (1997) on rust infestation in 'main' core collection indicated *Puccinia coronata* Corda as an casual agent of 60% of rust visible symptoms and *Puccinia graminis* Pers for the rest of symptoms. The highest differentiation of ecotypes according to rust infestation symptoms were observed in summer, at the initial stage of disease. Ecotype from Sweden (no. 34) was infected at the highest level in both experiments. Chorlton and Thomas (1987) received similar results in laboratory examination on susceptibility of ryegrass ecotypes for Puccinia coronata infestation where Swedish ecotypes exposed low rust resistance.

It is worth to indicate that in our experiment none of tested ecotypes exposed lower infestation than Polish variety Arka.

Abundance of inflorescences was negatively correlated with number of days to heading and it was also indicated that ecotypes originating from north Europe produced lower amounts of heads. It is probably due to different life strategies of ecotypes originating from different regions (Lorenzetti *et al.* 1971, Breese 1989 after Breese and Tyler 1986). Ecotypes from Romania exposed high values of abundance of inflorescences after first cut similarly to results of Charmet and Balfourier (1991).

The key role of origin in overall ecotype performance, as indicated in above work, was also suggested by Lorenzetti *et al.* 1971, Balfourier and Charmet 1991, Charmet *et al.* 1993, Loos 1994, Casler 1995, Amin and Thomas 1996.

Preliminary observations on mean heading dates and winter damages, received in other institutions co-operating in perennial ryegrass core collection (Marum *et al.* 1997) as well as conclusions coming from other researchers (Charmet *et al.* 1990, Elgersma 1990 a,b, Charmet and Balfourier 1991, Solberg *et al.* 1994) strongly support the multisite evaluation of collections. It is especially recommended for traits of low heritability, with high dependence on environmental conditions. Therefore, to receive more complete information on the nature of variation of European perennial ryegrass ecotypes and its interaction with environment, it is necessary to discuss joined results from other countries.

Above results strongly support development of core collection for other species stored in European gene banks.

Further conclusions from perennial ryegrass core collection evaluation in Bydgoszcz, Poland are as follows:

1. it is possible to indicate following regions of ecotype origin of mentioned species in Europe: south Europe, west Europe, north-middle Europe and Romania and Hungary;
2. none of tested ecotypes exposed better yield formation than control varieties, however few ecotypes appeared to have better particular traits (better winter performance, faster spring regrowth etc.);
3. high differentiation of ecotypes examined indicate existence of many botanical varieties as well as ecotypes of transition nature;
4. traits associated with inflorescence morphology (distance between florets in spikelet and distance between spikelets in spike, length of spikelet) seems to be the most stable traits, as contrary to abundance of inflorescences, tendency to produce inflorescences in year of sowing and green matter yield of first cut.

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