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Yield and Forage Quality of Romanian Red Clover (*Trifolium pratense* L.) Varieties Studied in Slovakia

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Abstract

In the experiment conducted from 2001 to 2003 at the experimental station of SARC-Research Institute of Plant Production in Piešťany, the agronomic and forage quality traits of five diploid Romanian red clover varieties coming from a red clover trial of Slovak and foreign varieties were evaluated. The traits studied were: green matter yield, plant height, regrowth intensity, number of stems, leaf/stem ratio, crude protein, crude fibre, fat and ash contents. Analysis of variance revealed highly significant differences ($P < 0.01$) among varieties for all agronomic traits except of stem number. Regarding forage quality traits, there were no significant differences between varieties, except in fat contents in the second production year ($P<0.05$). Cuts revealed a significant source of variation ($P < 0.01$) for all evaluated traits. The best agronomic performance was found in the first cut and the best forage quality was provided from the second cut. Romanian varieties were comparable with Slovak varieties. Velikan variety showed the best agronomic performance and also good forage quality. Select-1 and Transilvania cultivars exceeded majority Slovak varieties in all agronomic traits. According to PCA crude protein, crude fibre, fat, green matter yield and number of stems appeared to be the major source of variability. Using cluster analysis procedure varieties were classified into six homogeneous groups, based on particular agronomic traits or forage quality parameters.

Keywords: red clover, diploid Romanian varieties, yield potential, forage quality

Introduction

Red clover is an important forage legume grown in temperate regions throughout the world. Red clover is adapted to a wide range of climatic conditions, soil types, fertility levels, use patterns and management. It is easy to establish, has high seedling vigour, is an excellent nitrogen fixer, and is suiTab. for use in crop rotations. The yield potential of red clover is excellent and some red clover varieties can have higher fodder yields than alfalfa. Red clover is also of very good quality in the light of its nutritive value and ensiling (Taylor and Quesenberry, 1996; Hoffman and Broderick 2001).

Red clover varieties with higher yield, better persistence, and greater pest resistance have been developed and released in the last decade by private and public plant breeders. Careful selection of the best variety from the large number of varieties available can be one of the most important factors affecting yield, stand persistence, and potential profit. Plant genetic resources kept in gene banks are a rare and irreplaceable source of genes and gene complexes for research work and plant breeding. The characterisation of genetic resources helps to take advantage of the genetic diversity accessible in collections and the assessment of genetic resource collections provides information of the variability of attributes (Jahufer *et al.*, 1994). Evaluation of germplasm collections under field conditions is obviously recognized as a general method to estimate genetic variability. Using specific descriptors of morphological, phenological, agronomic and other characters of gene resources are used for estimating genetic variation and can be differentiated for practical breeding aims.

Present work is aimed at characterization of selected Romanian varieties and at comparison of their yield potential and some forage quality traits with Slovak varieties, grown in the conditions of the experimental station in Piešťany, Slovak Republic.

Materials and methods

The agronomic and forage quality traits of five diploid Romanian red clover varieties (Transilvania, Velikan, Roxana, Select-1, Flora) coming from a red clover trial of Slovak (Viglana, Manuela, Poľana) and foreign varieties are evaluated in this paper. The experiment was conducted during three years (2001-2003) at the experimental station of SARC-Research Institute of Plant Production in Piešťany. The experimental station is situated at an altitude of 163 m. The area has a continental climate with a mean annual temperature of 9.2°C and mean annual precipitation of 595

mm. The annual precipitation for the years studied ranged from 359 to 632 mm, and the mean monthly temperature varied between -0.6°C in January and 23.6°C in July. The soil at the experimental station site is Haplic Phaeozem, characterised as clay-loamy soil.

Red clover varieties were sown in May 2001. The experimental design was a randomised complete block with three replications. The plot size was 2.25 m^2. The plots were cut three times in the first and second years and two times in the third year. The varieties were harvested in comparable growth stage, at the beginning of flowering. At each harvest green matter yield per plot (calculated in $t*ha^{-1}$), number of stems and plant height (measured before cut, five times per plot) were observed. Regrowth intensity was assessed twenty days after each cut, five times per plot. At the second cut of the first year and at each cut of the second year a sample of 1 kilo was randomly taken for leaf-stem (L/S) ratio and forage quality traits determination. Herbage samples for quality assessment were dried at a temperature of 60°C for 72 hours and analysed using near infrared reflectance spectroscopy (NIRS). In this paper crude protein (CP), crude fibre (CF), fat and ash contents are considered. For the experiment analysis of variance was performed to determine variations and differences between varieties. Data for each genotype were averaged across the replications, cuttings and the growing years and used for cluster analysis and principal component analysis.

Results and discussion

Analyses of variance (Tab. 1) revealed highly significant differences between varieties for all agronomic traits except the number of stems and L/S ratio. Average data of particular years for Slovak and Romanian varieties are shown in Tab. 1. The mean values of evaluated traits for all varieties over the period of 2001 to 2003 are presented in Tab. 2.

Achieved results confirmed good production potential of all Romanian varieties, which were comparable with Slovak varieties. From the viewpoint of average green matter yield the best was Velikan variety. Among the Romanian varieties, also Select-1 and Transilvania provided higher green matter yield than varieties than Viglana and Poľana. The second production year was distinct because of very unfavourable weather with high temperature and precipitation deficit. As a consequence the green matter yields were extremely low and the third cut could not have been conducted. Even in such extreme climatic conditions Romanian varieties provided comparable green matter yield with Slovak varieties, the highest yield was provided by Velikan variety.

Tab. 1. ANOVA F values for Romanian, Slovak and all evaluated varieties in 2001-2003

	Year	ROU	SVK	All	F (varieties)	F (cuts)
Green matter yield	2001	8.62	8.93	8.62	11.37**	55.98**
	2002	23.95	23.25	22.28	5.66**	1348.95**
	2003	5.43	5.41	5.32	7.78**	59.36**
Plant height	2001	298.53	288.21	281.14	2.81**	314.51**
	2002	559.13	552.81	523.75	2.86**	454.84**
	2003	375.67	373.62	343.7	2.82**	12.89**
Regrowth intensity	2001	208.61	202.5	198.60	2.36**	1740.01**
	2002	329.97	323.43	310.27	2.45**	180.16**
	2003	176.01	166.14	157.01	3.10**	
Number of stems	2002	128.09	122.78	122.69	1.21	87.41**
	2003	49.24	48.45	44.87	2.06*	58.22**
Leaf/stem ratio	2001	66.07	61.25	62.46	1.24	
	2002	52.85	51.61	54.84	1.35	50.66**
Crude protein	2001	212.46	215.44	212.04	0.57	
	2002	178.56	183.5	185.81	1.50	70.52**
Crude fibre	2001	221.02	218.73	220.69	0.58	
	2002	276.57	266.73	267.41	1.50	21.01**
Fat	2001	18.24	18.99	18.37	2.07	
	2002	16.17	17.63	17.17	1.77*	6.23**
Ash	2001	136.42	135.03	135.33	0.85	
	2002	11.5	111.7	112.54	1.08	80.79**

Tab. 2. The mean values of agronomic and forage quality traits for evaluated varieties

Variety	Origin	PH	GMY	RI	SN	LS	CP	CF	Fat	Ash
		mm	$t.ha^{-1}$	mm		%	$g.kg^{-1}$	$g.kg^{-1}$	$g.kg^{-1}$	$g.kg^{-1}$
Viglana	SVK	416.98	12.69	267.38	95.53	52.14	193.08	253.41	17.82	118,10
Manuela	SVK	401.35	13.88	260.95	94.07	52.25	192.53	248.27	18.50	116,40
Poľana	SVK	411.35	13.56	258.81	89.53	57.67	188.85	262.50	17.59	118,09
ULC 1395	POL	388.33	12.93	252.98	93.00	54.97	190.97	258.46	17.27	116,64
ULC 1495	POL	381.67	13.26	245.00	95.20	56.77	198.35	249.17	18.41	120,21
ULC 1595	POL	386.77	13.13	239.81	107.10	58.02	190.82	247.64	17.49	116,48
Transilvania	ROU	415.21	13.62	270.24	94.13	53.08	182.91	266.87	16.14	116,25
Velikan	ROU	426.90	13.99	264.52	101.20	55.71	192.52	258.79	17.45	121,26
Roxana	ROU	401.04	13.20	275.36	96.13	56.90	189.93	260.49	16.80	118,92
Select-1	ROU	423.23	13.77	271.43	98.07	54.34	186.16	264.97	16.37	115,62
Flora	ROU	409.48	13.06	260.12	94.00	59.72	183.63	262.28	16.69	116,59
Diana	HUN	417.08	12.99	264.76	88.07	51.93	180.11	268.95	15.65	112,65
Taplanszentkeresti	HUN	385.11	7.66	232.14	66.74	56.38	189.50	260.60	16.91	115,29
Nemaro	DEU	359.79	11.30	232.14	95.20	57.02	197.64	247.09	18.23	122,92
Pirat	DEU	401.46	12.71	259.76	88.80	52.68	194.86	253.18	18.23	116,33
AC Endure	CAN	366.35	12.74	256.43	91.07	56.31	182.90	260.49	15.89	116,63
Merviot	BEL	378.65	10.69	244.76	83.60	56.90	190.62	258.64	17.23	116,89
Mean		398,28	12.66	256.27	92.44	55.46	189.73	257.75	17.22	117.37
HSD (0.05)		34,03	1.59	23.78	27.03	10.24	20.61	20.75	2.67	10.91
HSD (0.01)		36,08	1.68	25.26	28.72	10.95	22.03	22.18	2.85	11.66

PH - plant height, GMY - green matter yield, RI - regrowth intensity, SN - number of stems, LS - leaf/stem ratio, CP - crude protein, CF - crude fibre

With reference to average plant height, varieties Velikan and Select-1 presented higher plant height than all Slovak varieties and Transilvania was higher than Manuela and Poľana. These results confirmed high contribution of plant height on yield production (Užík, 1993), the most productive varieties having also the highest plant height. Average data (Tab. 2) showed that the highest regrowth intensity was achieved by Romanian varieties Roxana, Select-1 and Transilvania. The stem number is a very important yield component. In comparison, Slovak varieties were exceeded by varieties Velikan, Select-1 and Roxana. Analyses of variance revealed highly significant differences *(P<0.01)* between cuts with the highest green matter

Tab. 3. Standardised weight of variables, eigenvalues, variance (%), cumulative variance (%) in first three PCs

	Principal component		
Variables	1	2	3
Green matter yield	0.165	0.549	-0.167
Plant height	0.341	0.294	0.198
Regrowth intensity	0.374	0.351	0.072
Number of stems	-0.017	0.536	-0.342
Leaf/stem ratio	-0.187	-0.150	-0.749
Crude protein	-0.444	0.182	0.247
Crude fibre	0.443	-0.179	-0.147
Fat	-0.409	0.232	0.315
Ash	-0.347	0.247	-0.263
Eigenvalues	3.944	2.551	1.206
Variation (%)	43.82	28.35	13.40
Cumulative variation (%)	43.82	72.17	85.57

Tab. 4. List of varieties in particular clusters and mean values of evaluated characters

Variables	Clusters					
	1	2	3	4	5	6
	Viglana	Poľana	ULC 1395	ULC 1495	Transilvania	Taplanszent.
	Manuela	Velikan	AC Endure	ULC 1595	Select-1	
	Pirat	Roxana	Merviot	Nemaro	Diana	
		Flora				
Green matter yield	13.09	13.45	12.12	12.56	13.46	7.66
Plant height	406.60	412.19	377.78	376.08	418.51	385.11
Regrowth intensity	262.70	264.70	251.39	238.98	268.81	232.14
Number of stems	92.80	95.22	89.22	99.17	93.42	66.74
Leaf/stem ratio	52.36	57.50	56.06	57.27	53.12	56.38
Crude protein	193.49	188.73	188.16	195.60	183.06	189.50
Crude fibre	251.62	261.02	259.20	247.97	266.93	260.60
Fat	18.18	17.13	16.80	18.04	16.05	16.91
Ash	116.94	118.72	116.72	119.87	114.84	115.29

yield, plant height, regrowth intensity and stem number in the first cut.

No significant differences occurred with respect to L/S ratio between evaluated varieties. Nevertheless Romanian variety Roxana showed the highest L/S ratio and Roxana, Velikan, Select-1 and Transilvania varieties had higher L/S ratio than varieties Viglana and Manuela. The influence of the cut manifested in significantly lower L/S ratio in the first cut, which confirmed the negative correlations between leaf-stem ratio and green matter yield and plant height, documented also by Julier and Huyge (1997).

The difference between varieties for forage quality traits were not significant except the fat contents in the second production year *(P<0.05)*. The achieved results have shown that out of all Romanian varieties the best forage quality was provided by Velikan and Roxana varieties with the higher CP, CF and ash contents and with the lower CF content than varieties Transilvania, Flora and Select-1. In comparison with Slovak varieties Velikan and Roxana showed higher ash content. The forage quality was significantly affected by the cut. The second cut provided forage with a significantly higher *(P<0.01)* crude protein, fat and ash content and significantly lower crude fibre content than other cuts.

The relative significance of evaluated characters was more apparent during principal component analyses. The principal components (PCs) with eigenvalue > 1.0 were used as the criteria to determine the number of PCs. The first three principal components were accounted for 53.82 %, 28.35 % and 13.40 %, respectively, of the total variation (85.57 %). Eigenvalues, variance (%), cumulative variance (%) and standardised weight of variables in first three PCs are presented in Tab. 3**.** Fig. 1 shows importance and relatedness of a certain trait to the respective PC axis. The first PC was associated with forage quality traits whereas the agronomic traits defined PC 2. Characters with high coefficients in the first (CP, CF, fat) and second PC (GMY, number of stems) appeared to be the major source of variability. The third component expressed differences in leaf/stem ratio.

The cluster analysis divided the genotypes into six groups. List of varieties in particular clusters and mean val-

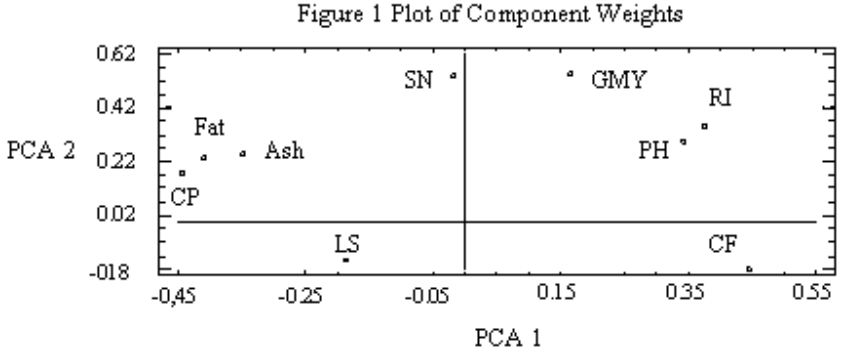

Fig. 1. Plot of component weights

ues of evaluated characters are presented in Tab. 4. Cluster 1 consisted of three genotypes, characterised by good agronomic performance and forage quality. One Slovak and three Romanian varieties of cluster 2 had high green matter yield, plant height, regrowth intensity and stem number, but they were varieties with low CP and high CF contents. In cluster 3 there are three genotypes reaching lower productivity and also weak forage quality. Cluster 4 comprised of three genotypes originally from Germany and Poland. They were varieties with poor agronomic performance, but they gave the forage with the highest quality. Cluster 5 created by Hungarian and Romanian varieties were characterised by the highest green matter yield, plant height, regrowth intensity and CF content. Cluster 6 included only one variety, which differed from the others by very low green matter yield and number of stems. Although several authors consider geographical origin as an essential factor of genetic variability (Williams, 1988; Julier *et al*. 1995), the clustering was independent on the country of origin. In our study, the evaluated varieties created homogeneous groups specific by particular agronomic traits or forage quality parameters.

Conclusions

The results of this study showed that regarding to productive potential, Romanian varieties were comparable with Slovak varieties. They provided high green matter yield, plants were tall with high number of stems and they were characterised by high regrowth intensity. Our study showed that the Velikan variety was more productive than all Slovak varieties and varieties Select-1 and Transilvania provided higher yield than varieties Viglana and Poľana. With reference to forage quality traits, there were no significant differences between evaluated varieties. The best forage quality of all Romanian varieties was provided by Velikan and Roxana varieties.

Analyses of variance revealed highly significant differences between cuts with the highest green matter yield, plant height, regrowth intensity and stem number in the first cut. Similarly the forage quality of evaluated varieties was significantly affected by cut. The second cut presented forage with a significantly higher crude protein, fat and ash contents and significantly lower crude fibre content than other cuts.

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