

BREEDING OF RED CLOVER VARIETIES FOR CONVENTIONAL AND ORGANIC AGRICULTURE

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Abstract

Red clover is a major perennial forage legume grown for forage on arable land in Lithuania and has great impact on economy and environmental quality. In terms of productivity and forage quality it does not lag much behind lucerne. The main problems of clover cultivation are clover rot, root rot and persistence. To solve these problems we used various breeding methods under natural and artificial infection. Nine varieties of red clover with different earliness, ploidy and disease resistance have been bred in Dotnuva, six of which have already been registered in Lithuania. These varieties perform well in terms of productivity and forage quality and are grown successfully in both conventional and ecological farming systems. The old varieties 'Liepsna' and 'Kamaniai' produced lower yield than the latest varieties, however, during the long cultivation period they have adapted very well to local agroclimatic conditions. Of special importance was the variety 'Arimaičiai' which produced a high yield for 2-3 years of use and appeared well suited to continuous growing. The tetraploid clover varieties 'Vyliai' and 'Kiršiniai' were also valuable. However, the low seed yield produced by these varieties prevents their spread in large scale production areas. The latest varieties of red clover 'Sadūnai' and 'Radviliai' were transferred to the State Variety Testing Trials. Thus, there is a diverse range of varieties of red clover for growing both in conventional and ecological farming systems. Since 2003 most of the listed varieties have been tested for DUS. The varieties 'Arimaičiai' and 'Vyčiai' were included in the EU variety list in 2006.

Key words: varieties, yield, resistance, diseases, quality.

Introduction

There is little evidence to show when red clover was first grown in Lithuania. In 1815 in the daily paper "Dziennik Vilenski" published in Vilnius Paškevičius wrote that in 1811 red clover was grown in the crop rotation in Vilnius province in Ščorsai, on Chrebtavičius farm. According to Semionov the first red clover was cultivated in Belarus in 1813. Moreover, he noted that first clover seeds were imported from the Baltic States /Semenov, 1965/. Thus one can assume that cultivation of red clover in Lithuania started at least as early as 1811.

Until the late 19th century the area sown with red clover hardly changed. In 1901 the area under perennial grasses (including red clover) in Lithuania accounted for 2.61 % of the arable area. From the early 20th century the area of clover started to increase rapidly. In 1938 the area amounted to 445,550 ha, some 16.2 % of the total arable land /Vazalinskas, 1937/. In 1958 in Lithuania the area of red clover and its mixtures with grasses reached 484,400 ha or 20.1 % of the total arable land. Large amounts of clover seed were exported. Currently due to the prolonged agricultural reform and changes in land use the area of perennial grasses, including clover, is much smaller.

Red clover is a major perennial forage legume grown for forage on arable land in Lithuania and has a great impact on environmental quality. In terms of productivity and forage quality it does not lag much behind lucerne. The economic and ecological significance of red clover for our agriculture was very highly valued by prof. P. Vasinuskas (1989). The main problems of red clover cultivation are clover rot, root rot and persistence. Various methods of breeding under natural and artificial infection were used to solve these problems.

Clover breeding was begun with the establishment of the Dotnuva Breeding Station in 1922. No red clover varieties were developed in Lithuania until the Second World War. The first early red clover diploid variety 'Liepsna' was released in 1957, late diploid variety 'Kamaniai' in 1959, early tetraploid variety 'Vyliai' in 1990, medium-late diploid variety 'Arimaičiai' in 1996, late tetraploid variety 'Kiršiniai' in 1996 and early diploid variety 'Vyčiai' in 2002 (Table 1).

Table 1. The red clover varieties developed from the beginning of breeding work until 2006.

1 lentelė. Raudonųjų dobilų veislės, sukurtos Dotnuvoje nuo selekcinio darbo pradžios iki 2006 m.

Dotnuva, 1922-2006

Variety <i>Veislė</i>	Type <i>Tipas</i>	Ploidy <i>Ploi- dišku- mas</i>	Resistance to root rots <i>Atsparumas šaknų puviniams</i>	Year of transfer to official testing <i>Perduota veislių tyrimams</i>	Year of registra- tion <i>Regist- racija</i>
Liepsna	Early / <i>Ankstyva</i>	2 n	Susceptible / <i>Neatspari</i>	1952	1957
Kamaniai	Late / <i>Vėlyva</i>	2 n	Susceptible / <i>Neatspari</i>	1954	1959
Vėlyviai	Very late / <i>Labai vėlyva</i>	2 n	Resistant / <i>Atspari</i>	1974	-
Vyliai	Early / <i>Ankstyva</i>	4 n	Resistant / <i>Atspari</i>	1985	1990
Kiršiniai	Late / <i>Vėlyva</i>	4 n	Resistant / <i>Atspari</i>	1990	1996
Arimaičiai	Semiate / <i>Pusiau vėlyva</i>	2 n	Very resistant / <i>Labai atspari</i>	1993	1996
Vyčiai	Early / <i>Ankstyva</i>	2 n	Resistant / <i>Atspari</i>	1995	2002
Sadūnai	Very early / <i>Labai ankstyva</i>	4 n	Very resistant / <i>Labai atspari</i>	2005	-
Radviliai	Early / <i>Ankstyva</i>	2 n	Very resistant / <i>Labai atspari</i>	2006	-

Nine varieties of red clover with different earliness, ploidy and disease resistance have been bred in Dotnuva, six of which have already been registered in Lithuania.

The above-listed varieties are well-adapted to Lithuania's agroclimatic conditions and are successfully spreading in the country. The varieties 'Arimaičiai', 'Sadūnai' and 'Radviliai' exhibit good resistance to crown rot (*Sclerotinia trifoliorum* Erikss.) and root rot (*Fusarium* spp.) produce a high yield for 2-3 years of use and can well withstand continuous growing because they were bred by using artificial infection and after many years of re-sowing in a special nursery. These varieties are very important for ecological farming where clover is re-seeded every 2-3 years in a crop rotation.

Red clover breeding is being continued at the Lithuanian Institute of Agriculture. The Institute's best red clover varieties are currently being tested for distinctness, uniformity and stability (DUS testing) in Poland. The varieties 'Arimaičiai' and 'Vyčiai' were included in the EU variety list in 2006.

Materials and methods

Clover breeding, as well as breeding of other perennial legumes, is conducted at the Lithuanian Institute of Agriculture's experimental department in the field of a six-course crop rotation of forage grasses. The soil of the experimental site is *Endocalcaric-Endohypogleyic Cambisol* CMg-n-w-can (pH – 7.3, P₂O₅ – 201-270 mg kg⁻¹ and K₂O – 101-175 mg kg⁻¹, humus – 2.46 %). Clover is sown after a black fallow without a cover crop. Breeding nurseries and variety testing trials of perennial legumes are used for two years. NPK fertilizers and pesticides are applied only to the cereals grown in the crop rotation, therefore the developed varieties are also well-suited for ecological farming. The weather conditions during the 2001-2005 period were diverse and had a different impact on red clover growth and yield.

The following methods are used in red clover breeding: mass, individual, and family selection, polyploidy, polycross, topcross, intervarietal crossing, recurrent selection and others /Svirskis, 1995; Kilčevskij, Chotyleva, 1997; Sprainaitis et al., 2003/.

The size of the experimental plots was 10-30 m². The plots were replicated 3-4 times.

The experimental data were processed by statistical methods, using a software package "Selekcija" /Tarakanovas, 1999/.

Results and discussion

Red clover is affected by about 100 various diseases /Strukčinskas, 1974/. Diseases and adverse agroclimatic conditions determine not only clover yield, quality but also persistence. Quite often clover persists for only one or two years. As a result, in the development of new clover varieties we employ various methods of natural and artificial infection in the infection nursery established in 1970. Here clover selection is conducted against a background of artificial clover rot (*Sclerotinia trifoliorum* Erikss.) and root rot infection and continuous growing. In the crop rotation the red clover variety 'Arimaičiai' is characterised by a high dry matter and seed yield for 2-3 years of use, can well withstand continuous growing and is especially suited for ecological farming,

where clover is re-seeded every 2-3 years in the crop rotation /Svirskis, 1995; Kadžiulis, 2001; Kadžiulis, Kadžiulienė, 2002; Kadžiulienė, 2004/.

Table 2. Yield data of the three varieties and one promising breeding line of red clover of 2001 and 2002 sowing year

2 lentelė. 2001 ir 2002 sėjos metų 3 veislių ir vienos perspektyvios raudonųjų dobilų linijos derliaus duomenys

Donuva, 2001-2004

Variety and promising line <i>Veislė ir linija</i>	Height cm <i>Aukštis cm</i>			Herbage yield <i>Žolės derlius</i>		DM yield <i>SM derlius</i>	
	1 st crop <i>I žolė</i>	2 nd crop <i>II žolė</i>	3 rd crop <i>III žolė</i>	t ha ⁻¹	%	t ha ⁻¹	%
	2001 sowing year / <i>Sėjos metai</i>						
1 st year of use / <i>I naudojimo metai (2002)</i>							
Arimaičiai st., 2n	42	30	22	34.6	100.0	11.3	100.0
Radviliai, 2n	44	26	18	39.0	112.7	12.6	111.5
Sadūnai, 4n	50	46	16	44.4	128.3	14.1	124.8
Promising line No. 33, 2n <i>Perspektyvi linija No. 33, 2n</i>	50	44	19	41.3	119.4	13.4	118.6
LSD ₀₅ / R ₀₅				3.0		1.3	
2 nd year of use / <i>II naudojimo metai (2003)</i>							
Arimaičiai st., 2n	30	30	20	21.4	100.0	6.7	100.0
Radviliai, 2n	34	32	21	25.4	118.7	8.2	122.4
Sadūnai, 4n	36	34	24	31.1	145.3	9.8	148.3
Promising line No. 33, 2n <i>Perspektyvi linija No. 33, 2n</i>	30	30	25	19.2	89.7	6.1	91.0
LSD ₀₅ / R ₀₅				8.0		3.0	
2002 sowing year / <i>sėjos metai</i>							
1 st year of use / <i>I naudojimo metai (2003)</i>							
Arimaičiai st., 2n	50	46	25	48.8	100.0	14.9	100.0
Radviliai, 2n	48	54	30	49.3	101.0	15.4	103.4
Sadūnai, 4n	52	54	38	56.2	115.2	16.6	111.4
Promising line No. 33, 2n <i>Perspektyvi linija No.33, 2n</i>	52	54	30	55.2	113.1	16.9	113.4
LSD ₀₅ / R ₀₅				4.6		1.4	
2 nd year of use / <i>II naudojimo metai (2004)</i>							
Arimaičiai st., 2n	32	63	-	55.3	100.0	12.7	100.0
Radviliai, 2n	30	72	-	42.2	87.2	12.6	99.2
Sadūnai, 4n	36	70	-	51.5	93.1	12.6	99.2
Promising line No. 33, 2n <i>Perspektyvi linija No. 33, 2n</i>	36	70	-	52.0	94.0	12.9	101.6
LSD ₀₅ / R ₀₅				6.5		1.7	
Averaged data from two trials / <i>Dviejų bandymų vidutiniai (2001-2004)</i>							
Arimaičiai st., 2n	38	42	22	40.1	100.0	11.4	100.0
Radviliai, 2n	34	45	23	40.5	101.0	12.2	107.0
Sadūnai, 4n	43	51	26	45.8	114.2	13.3	116.7
Promising line No.33, 2n <i>Perspektyvi linija No. 33, 2n</i>	42	49	24	41.9	104.5	12.4	108.8
LSD ₀₅ / R ₀₅				5.0		1.6	

The tetraploid clover ‘Vyliai’ and ‘Kiršiniai’ are high- yielding and possess a rather high disease resistance. The greatest drawback of these varieties is a low seed yield. For example, in the year 2004, which was unfavourable for seed clover, ‘Vyliai’ and ‘Kiršiniai’ matured as little as 100 kg seed per 1.5 ha area, whereas ‘Arimaičiai’ produced 400 kg of seed of the 1st grade on the same area. In 2005, this variety matured as little as 400 kg of seed per ha on an area of 20 ha in the Dotnuva experimental farm. The old and stable varieties ‘Liepsna’ and ‘Kamaniai’ that have passed a long process of natural selection and adaptation to local agroclimatic conditions are also valuable for 1 or 2 years of use.

The tetraploid breeding line No.31 (‘Sadūnai’) (breeder A. Svirskis) was transferred to the Official Testing and for DUS testing in Poland in 2005. It is a hybrid population of very early plants, selected from various varieties in breeding nurseries and freely cross- pollinated in the infection nursery. The data from the two experiments suggest that this breeding line surpasses the standard variety ‘Arimaičiai’ in dry matter yield by 16.7 % and only slightly lags behind in terms of persistence and resistance to continuous growing (Table 2).

Table 3. Seed yield of the new varieties and one promising line in the first year of use
3 lentelė. *Naujų veislių ir vienos perspektyvios linijos sėklų derlius pirmaisiais naudojimo metais*

Dotnuva, 2002, 2003 and 2004

Variety and promising line <i>Veislė ir linija</i>	Beginning of flowering <i>Žydėjimo pradžia</i>	Height cm <i>Aukštis cm</i>	Seed yield g /30 m ² <i>Sėklų derlius g / 30 m²</i>	%
2001 sowing year / <i>sėjos metai</i>				
Arimaičiai, st.	06 12	71	400	100.0
Radviliai, 2 n	06 02	70	455	113.8
Sadūnai, 4 n	05 28	72	250	62.5
Promising line No. 33, 2n <i>Perspektyvi linija No. 33, 2n</i>	06 02	68	440	110.0
2002 sowing year / <i>sėjos metai</i>				
Arimaičiai st.	06 06	67	495	100.0
Radviliai, 2 n	05 28	70	720	145.4
Sadūnai, 4 n	05 25	64	228	46.1
Promising line No. 33, 2n <i>Perspektyvi linija No. 33, 2n</i>	05 28	68	535	108.0
2003 sowing year / <i>sėjos metai</i>				
Arimaičiai st.	06 20	52	461	100.0
Radviliai, 2 n	06 08	56	360	78.1
Sadūnai, 4 n	06 08	58	264	57.3
Promising line No. 33, 2n <i>Perspektyvi linija No. 33, 2n</i>	06 10	54	293	63.6
Average 2002, 2003 and 2004 / <i>vidurkis</i>				
Arimaičiai, st.	06 14	63	452	100.0
Radviliai, 2 n	06 03	65	512	113.0
Sadūnai, 4 n	05 30	65	247	54.7
Promising line No. 33, 2n <i>Perspektyvi linija No. 33, 2n</i>	06 04	63	423	93.6

Rather promising and homogeneous is the variety ‘Radviliai’ (breeder A. Svirskis). It is a productive early, diploid clover population. The initial breeding material was collected by prof. S. Juknevičius in Noreikiškiai (Kaunas district) and in the vicinity of the river Nemunas. Hybridisation of this population of early diploid ecotypes, selected for many years from many varieties in the infection nursery and continuous growing were performed in Dotnuva. The data averaged over the two experiments suggest that ‘Radviliai’ surpassed the standard ‘Arimaičiai’ in dry matter yield only by 7.0 %, but the seed yield was higher by 13,3 % (Table 3).

This variety also exhibited a good persistence and resistance to continuous growing. In 2006 the variety ‘Radviliai’ was transferred to the State Variety Testing and for DUS testing in Poland. These varieties are characterised by a good chemical composition and digestibility (Table 4).

Table 4. Chemical composition (in %) of the new varieties and one promising line
4 lentelė. Naujų veislių ir vienos perspektyvios linijos cheminė sudėtis
Dotnuva, 2002

Variety and catalogue No. <i>Veislė ir katalogo Nr.</i>	NIRS				Chemical analysis <i>Cheminė analizė</i>	
	Crude protein <i>Žali baltymai</i>	Digestibility PC Digest <i>Virškinamumas</i>	Fibre <i>Ląsteliena</i>	Digestibility enzymatic b. <i>Virškinamumas fermentinis</i>	Protein <i>Baltymai</i>	Fibre <i>Ląsteliena</i>
	1 st crop (beginning of flowering) / <i>I žolė (žydėjimo pradžia)</i>					
Arimaičiai, st., 2n	17.96	68.44	19.69	71.8	17.4	23.42
Sadūnai, 4n	19.33	67.22	20.56	78.0	17.6	20.71
Radviliai, 2n	21.25	66.46	27.09	76.7	21.9	24.66
Promising line No. 33, 2n <i>Perspektyvi linija No.33, 2n</i>	19.10	70.20	20.18	79.0	18.6	18.90
	2 nd crop / <i>II žolė</i>					
Arimaičiai, st., 2n	19.53	61.87	20.30	72.1	18.5	19.57
Sadūnai, 4n	17.34	57.59	26.52	68.2	16.6	24.12
Radviliai, 2n	16.69	58.08	27.48	66.2	16.1	26.46
Promising line No. 33, 2n <i>Perspektyvi linija No.33, 2n</i>	19.35	70.40	20.51	69.4	18.4	19.44

The analyses were done at LIA Analytical laboratory / *Analizės atliktos LŽI Cheminių tyrimų laboratorijoje*

As a result, there is a rather vast choice of varieties of red clover bred in LIA for growing both in conventional and ecological farming.

Conclusions

1. During the period 1957-2006 there were registered in Lithuania 6 varieties bred at the Lithuanian Institute of Agriculture.

2. The highest dry matter yield among the new varieties was produced by the tetraploid, very early variety ‘Sadūnai’. The highest seed yield was produced by the diploid, early variety ‘Radviliai’. They are resistant to crown and root rot, have good

persistence and their dry matter is characterised by a good chemical composition. The varieties are performing well at the State Variety and DUS testing.

Received 18 09 2006

Accepted 20 11 2006

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RAUDONŪJŲ DOBILŲ VEISLIŲ SELEKCIJA INTENSYVIOS IR EKOLOGINĖS ŽEMDIRBYSTĖS SISTEMOMS

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Santrauka

Raudonieji dobilai – pagrindinė daugiamečių ankštinių žolių rūšis, auginama ariamose dirvose Lietuvoje ir turinti didelę ekologinę ir ekonominę reikšmę. Pagal derlingumą ir pašaro kokybę nedaug atsilieka nuo liucernų. Svarbiausia raudonųjų dobilų auginimo problema – dobilų vėžys (*Sclerotinia trifoliorum* Erikss.), šaknų puviniai ir dažnas išnykimas jau po pirmų naudojimo metų. Nuo 1970 metų, selekcionuojant dobilų veisles, pradėtas naudoti infekcinis augynas, kur dobilai dirbtiniu būdu užkrečiami dobilų vėžiu ir šaknų puvinių sukėlėjais. Daugkartinio atsėliavimo ir dirbtinės infekcijos fone diploidinė vėlyvųjų raudonųjų dobilų veislė ‘Arimaičiai’ atspari minėtoms ligoms, pakenčianti net atsėliavimą ir duodanti gerą sėklų ir sausųjų medžiagų derlių 2-3 metus. Nuo 2006 metų ši veislė įrašyta į ES bendrąjį žemės ūkio augalų veislių katalogą.

Pastaraisiais metais į Valstybinius veislių, taip pat į stabilumo, išskirtinumo ir vienodumo (DUS testas) tyrimus Lenkijoje perduotos dvi naujos derlingos, atsparios ligoms raudonųjų dobilų veislės – tai tetraploidinė ankstyva veislė ‘Sadūnai’, ir ankstyva diploidinė veislė ‘Radviliai’. Sėkmingas šių veislių įdiegimas į gamybą turėtų prisidėti prie Lietuvos tausojamosios žemdirbystės sistemos sukūrimo.

Reikšminiai žodžiai: veislės, derlius, atsparumas ligoms, kokybė.