Effect of provenance and ploidity of red clover varieties on productivity, persistence and growth pattern in mixture with grasses

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ABSTRACT

In temporary and permanent grasslands, red clover distinctly increases herbage quality and production at low fertilization requirements. Main disadvantage of this species is its insufficient persistence. There are considerable differences in persistence among varieties, which are connected with different adaptability and disease resistance. In this experiment, we assessed the production of dry forage, number of plants and growth differences in eight tetraploid and fourteen diploid varieties grown in mixture with grasses. The highest production of forage for both harvest years was achieved by Czech varieties Spurt and Amos and by Swiss variety Milvus. The lowest forage production was recorded in both years in Swedish one-cut varieties Betty, Jesper and SW Torun. In the second production year, the most yielding was German variety Lucrum, followed by Czech varieties Spurt and Amos. The highest cover in the third production year was reached by Swiss variety Artus (87.8%) while the lowest cover was recorded in Austrian variety Reichersberger Neu (40.0%). Tetraploid varieties exhibited significantly lower contents of dry matter but their productivity and persistence did not differ from diploids. Very suitable for long-term use thus appear Swiss varieties of Mattenklee type (Artus, Milvus), German variety Lucrum and Czech varieties Amos, Spurt and Start.

Keywords: variety testing; dry matter yield; cover estimation

Red clover was introduced in the European agriculture approximately 1000 years ago in Andalusia, Spain and from there, its cultivation spread to other countries (Kjaergaard 2003). In the territory of the Czech Republic, the red clover has been intentionally grown already for 280 years (seed purchase was first mentioned to occur in 1730) and its contribution to the intensification of cattle rearing and production of cereals has been significant (Lom 1937). Before the discovery of synthetic production of nitrogen from the atmosphere in 1909 by German chemist Fritz Haber, the main source of nitrogen for agricultural crops was symbiotic fixation of red clover and other legumes. The production of synthetic N fertilizers markedly increased after World War II, which resulted in a rapid shrinkage of red clover cropland in Europe and North America (Taylor 2008). The size of clover crop fields continues to diminish on a global scale. According to Rochon et al. (2004), the size of clover crop fields in Europe lessened from 9.5 million ha in 1980 to 6.0 million ha in 2000.

At the present time, we can see a certain increase of interest in growing forage legumes including red clover because of increasing energy costs and deteriorating environmental effects of synthetic nitrogen use. Another reason for the greater interest in clover crops is an increasing significance of organic farming and increased price of protein concentrates after prohibition of meat-bone meals in feeding animals.

Red clover is the most important clover crop on moist, less fertile and acidic soils while alfalfa predominates in drier regions on deep soils with neutral reaction. Although the forage of alfalfa contains more crude protein as compared with red clover, the advantage of red clover is the presence of enzyme polyphenol oxidase (PPO), which improves protein efficiency during digestion of ruminants (Sulivan and Hatfield 2006) and suppresses proteolysis during forage ensiling (Pahlow 2003). Red clover is suitable in mixtures with grasses that enhance ensiling capacity and reduce damage to

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clover plants by pathogens and means of mechanization. The lower admixture of companion grasses does not inhibit fixation of atmospheric nitrogen. In the conditions of northern Germany, Loges et al. (2001) recorded in red clover and clover grass stand fixation of 300–310 kg N/ha.

In central Europe, red clover is a native species of permanent grasslands. Regal and Štráfelda (1959) conclude from their phytocoenological research that it is the most abundant legume in semi-natural grass stands. It is tolerant to shading and can easily find place in high yielding stands, too, where its long-term persistence is provided by natural seeding namely in the aftermath. However, wild forms have low productivity and this is why they have never been used intentionally at a greater extent (Kjaergaard 1994). In the Czech Republic, there are currently 28 registered varieties from the national breeding of red clover (13 diploids and 15 tetraploids) and the size of certified seed-growing plots in 2007 amounted to 7177 ha with the production of 1549 tons of seed. Red clover seed is a valuable product for export.

Red clover is currently grown especially in pure stands on arable land (sown alone) or in clover-grass mixtures and at a limited extent also in permanent swards. Choo (1984) informs that red clover is a naturally short lived perennial plant and a great effort of breeders is given therefore to increase its resistance to cold and to enhance its persistence. Its main disadvantage is low persistence because most plants die in the third or fourth year after sowing (Abberton and Marshall 2005). As to persistence, the existing varieties show considerable differences, though (e.g. Dunea 1998, Lehmann and Briner 1998). This is why most red clover breeding programmes put a primary emphasis on persistence (Taylor 2008). The highest persistence is declared in the Swiss varieties of Mattenklee type, which are preferably used in swards (Lehmann and Briner 1998). Sheldrick et al. (1986) reports that the growing cycle of red clover is normally considered in the UK to be two years; however, if the attack of diseases and pests is low, it is normal to expect a productive lifetime of 6–8 years. Red clover is grown even in colder regions of Brazil, but the main disadvantage of local varieties is their low persistence associated with poor adaptability (Montardo et al. 2003).

The objective of this paper is to evaluate differences in yield, persistence and other features important with respect to agricultural production among 22 red clover varieties from different countries of origin grown in simple mixtures with grasses. The most persistent varieties should be used preferably for lays and for the establishment of permanent grasslands or sod seeding. The use of more persistent varieties would lead to reduced requirements of nitrogen fertilizers, increased forage yield and quality as well as to extended intervals between red clover seeding into sod. This would consequently lead to decreased inputs in cattle rearing and reduced costs of animal products (Komárek et al. 2007). Although the persistence of red clover was assessed by many authors (mostly as monocultures) with respect to linkage in adaptability, it is necessary to test it under local conditions together with grass companion.

MATERIAL AND METHODS

Experimental site. The trial was established on 9 June 2006 by drilling into rows 125 mm at the Forage Research Station in Vatín (49°15'5''N, 15°58'15''E) belonging to the Mendel University in Brno, Czech Republic. The site is situated at the altitude of 540 m a.s.l., mean annual precipitation and mean annual temperature (1971–2000) are 617.5 mm and 6.9°C, respectively. Soils are acidic cambisols, sandy loam developed on the deluvium of orthogneiss. Climatic and soil conditions of the station mirror most of forage producing areas occurring in the Czech Republic. Soil pH and plant-available nutrients determined by Mehlich III method (Mehlich 1984) are shown in Table 1. The soil was limed one year before the trial establishment by milled dolomite limestone after 20 years liming omission (the reason for low pH value).

Stand establishment, treatment and assessment. We sowed out 22 varieties of red clover of declared higher persistence (Table 2). The red clover varieties were sown in a mixture with meadow fescue and timothy. Sowing rates were 14 kg/ha of red clover, 4 kg/ha of meadow fescue and 6 kg/ha of timothy. The seed was not inoculated by any *Rhizobium* bacteria and the legumes were not grown at the same area at least 6 years before the trial establishment. The trial was established by the method of randomized plots in 4 repetitions

Table 1. Chemical parameters of the soil

pH	P	K	Ca	Mg	C_{ox}
($CaCl_2$)	(mg/kg)				(g/kg)
4.75	79.4	320.9	1040	112.8	11.8
Strong acid	moderate	high	low	moderate	low

Table 2. List of red clover varieties used in the trial based on their ploidity

Ploidity	
4*n*	2*n*
Amos (CZ)	Charlie (CAN)
Astur (CH)	Christie (CAN)
Beskyd (CZ)	Endure (CAN)
Betty (SE)	Gumpensteiner (A)
Dolina (CZ)	Jesper (SE)
Radegast (CZ)	Lucrum (D)
SW Torun (SE)	Milvus (CH)
Veles (CZ)	Nemaro (D)
	Pavo (2n, CH)
	Reichersberger Neu (A)
	Spurt (CZ)
	Start (CZ)
	Tedi (NL, F)
	Vltavín (CZ)

Abbreviations of the countries of origin are in the brackets

without a cover crop. No herbicides were used in this experiment. Rodenticides were applied each autumn to control field mouse (*Microtus arvalis*). The size of experimental plot was 1.25 × 4 m (5 m^2). In the year of sowing, the stand was harvested twice without assessment of production. In the two production years, the stands were harvested three times, the first and second time when 50% of flower heads opened in most varieties (2007: 14.6./1.8./16.10.; 2008: 17.6./28.8./8.10.). Cutting height was 60 mm. In the assessment of dry forage production, a composite sample was taken at each harvest from the respective varieties, which was oven-dried at 60°C. The experiment was fertilized only with 30 kg P (Hyperkorn) in the spring of production years; other mineral fertilizers were not used. This was to provide for similar conditions as in most of grasslands in the Czech Republic (acid soils, absence of mineral fertilizing).

The number of plants was assessed on stationary spots 0.5 × 0.5 m, on each plot in 2007, 2008 and 2009, always in April at the beginning of the growing season. The cover of red clover was estimated in June 2009, just before the first cut (Table 4). The intensity of infestation by mildew (*Erysiphe polygoni*) was assessed in the autumn.

Basic meteorological data were measured at meteorological station at the research site. Average temperature and precipitation data are shown in Table 4.

Statistical analysis. Statistical analyses were performed using ANOVA (Statistica 7.1, StatSoft) with multiple comparisons according to Tukey ($P < 0.05$). Assessment of difference in dry matter content between diploids and tetraploids was evaluated by *t*-test using the Levene test to judge homogeneity of variances. Evaluation of differences between one and two-cut type varieties was made by cluster analysis with complete linkage using the Euclidean distance.

RESULTS AND DISCUSSION

Productivity

Table 4 presents dry forage yields of individual red clover varieties for the two production years. It also brings a comparison of production in the second and in the first production year. Varieties with the highest ratio should be those with a higher persistence and better disease resistance (Halling et al. 2004).

Red clover gives the highest yields most frequently right in the first year after stand establishment. In our experiment, however, the production of forage in most varieties was higher in the second harvest year than in the first year, which was conditioned by weather. In 2007, the weather was dry and warm until the beginning of May (with only 0.1 mm rain from 25 March–5 May) and average temperature in April was by 1.7°C higher than long-term average. The spring growth of plants occurred early but the increased need of water for transpiration was not fully covered. In contrast, the year 2008 was favourable as to rain distribution, and this is why very high yields were achieved.

Table 3. Temperature and precipitation in Vatín in 2007 and 2008 in comparison with long-term average

	I–XII		Vegetation period (IV–IX)	
	av. temperature (°C)	precipitation (mm)	av. temperature (°C)	precipitation (mm)
30 years average (1971–2000)	6.9	617.5	13.1	374.0
2007	7.9	705.3	13.6	351.4
2008	7.7	716.5	13.1	458.8

Table 4. Production of forage (t/ha of dry matter) in two harvest years

Variety	Total 2007 + 2008	Total 2007	Total 2008	Proportion 08/07
Spurt	40.16^{c}	18.84^{b}	21.32^{bc}	1.13
Amos	39.41^{bc}	18.08^{b}	21.33^{bc}	1.18
Milvus	39.40^{bc}	18.85^{b}	20.55^{abc}	1.09
Christie	38.84^{bc}	19.37^{b}	19.47^{abc}	1.01
Lucrum	38.79^{bc}	16.14^{b}	22.65^{bc}	1.40
Beskyd	37.78^{bc}	17.70^{b}	20.08^{abc}	1.13
Start	37.66^{abc}	16.96^{b}	20.7^{bc}	1.22
Nemaro	37.6^{abc}	17.87^{b}	19.73^{abc}	1.10
Veles	37.39^{abc}	18.31^{b}	19.08^{abc}	1.04
Pavo	36.66^{abc}	16.40^{b}	20.26^{abc}	1.24
Endure	36.64^{abc}	18.35^{b}	18.29^{abc}	1.00
Dolina	36.39^{abc}	15.67^{b}	20.72^{bc}	1.32
Vltavín	35.94^{abc}	17.57^{b}	18.37^{abc}	1.05
Tedi	35.50^{abc}	18.94^{b}	16.56^{abc}	0.87
Astur	35.40^{abc}	15.05^{b}	20.35^{abc}	1.35
Charlie	33.18^{abc}	14.73^{ab}	18.44^{abc}	1.25
Radegast	33.13^{abc}	15.33^{b}	17.8^{abc}	1.16
Reichersberger Neu	32.88^{abc}	17.06^{b}	15.82^{abc}	0.93
Gumpensteiner	31.50^{abc}	14.48^{ab}	17.02^{abc}	1.18
Betty	29.06^{ab}	13.7^{ab}	15.36^{ab}	1.12
Jesper	28.68^{ab}	13.76^{ab}	14.91^{ab}	1.08
SW Torun	26.92^{a}	13.39^{ab}	13.53^{a}	1.01
SE	0.50	0.32	0.35	–

SE – standard error

The new Czech diploid variety Spurt gave the highest forage yield in both production years and was followed by another Czech tetraploid variety Amos and by the Swiss diploid variety Milvus. The lowest forage production was given by Swiss varieties Betty, Jesper and SW Torun, which related to their one-cut character (Figure 1). Lucrum, Astur and Dolina varieties showed the highest increase of forage production in the second production year while the lowest values of forage production were recorded in Tedi, Reichersberger (the yield even dropped) and Endure varieties.

The share of individual botanical constituents in yield was not assessed because the stands were not fertilized with nitrogen and grasses with other herbs represented only a small part. Their growth depended on the amount of nitrogen gained from the fixation of adjacent clover plants.

Persistence

In the previous experiment (Hejduk 2006) the persistence of 21 Czech red clover varieties grown with grasses was compared according to their cover percentage in the third harvest year. Varieties that showed to be the most persistent were used for the establishment of this experiment. The trial furthermore included some foreign varieties of declared higher persistence. Table 5 presents the number of plants per square meter in the respective harvest years and the share of survivals 4 years after sowing. The highest cover in the third production year was found in Astur variety while the significantly lowest values were recorded in the Austrian variety Reichersberger Neu. Nevertheless, Gerl (2000) informs that the variety is used in Austria for temporary lays and its persistence is satisfactory (at a share of 37% in sowing rate, its cover in the fourth production year was 7%). Interaction with environment might have played a role too. In general, the significance of differences was negatively affected by high variability between the repetitions.

Fergus and Hollowell (1960) present records about red clover stands aged nine and even more years; the heritability of persistence is probably not so high, because if the seed from these stands

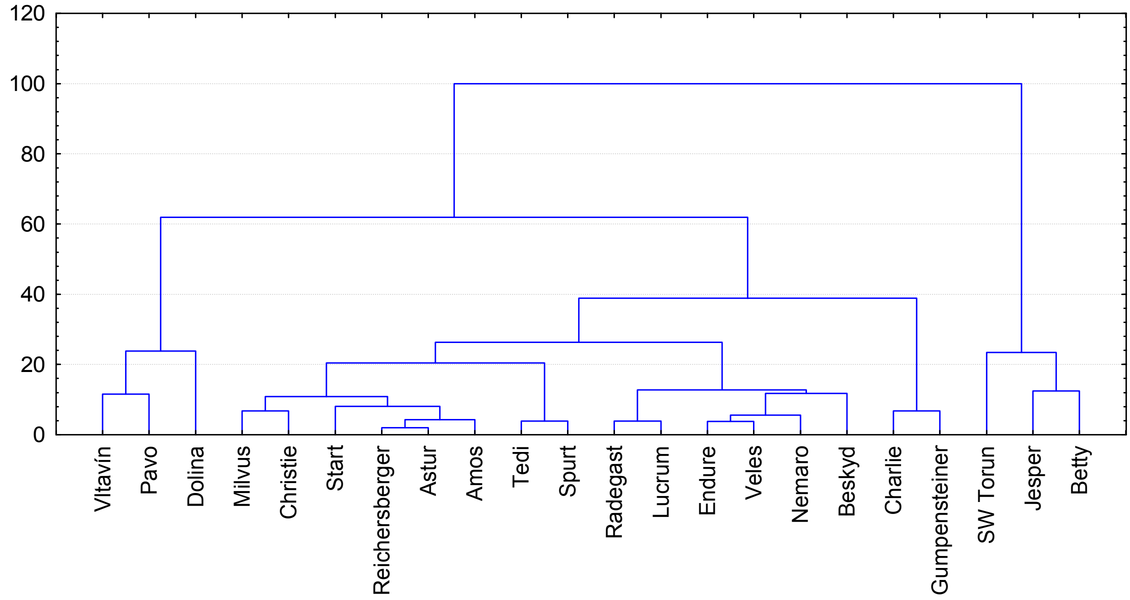

Figure 1. Dendrogram of red clover varieties based on their similarity in the percentage of the first cut in yearly production

is used in comparative varietal trials, the plants survive only 3–4 years. According to Marley et al. (2003), the limited persistence of red clover is contributed to by unfavorable conditions of the environment, agricultural technology and diseases. A progressive decline in annual DM production with age is typical of clover swards, even in the absence of pests and diseases, due to natural decline in plant populations (Frame et al. 1998). However, according to our observation and in compliance with some authors (e.g. Taylor 2008), genotype plays a great role in assessing the persistence. Lehmann and Briner (1998) and Dunea (1998) judge persistence in the same way as we did – according to cover percentage at the end of test period (usually in the third or fourth year after sowing) while others (Taylor and Queensberry 1996) by the capacity of the sward to provide adequate forage yield or by the longevity of individual plants (Taylor 2008). Haaling et al. (2004) determine persistence as an ability to continue in satisfactory yielding over a number of years. They use a so-called persistence index, which is a ratio of yields in the third and first production years. They found the red clover to reach, as an average from a great number of experiments in northern Europe, only 68% (max. 112.3% and min. 17.8%) while the white clover, alfalfa and broadleaved birdsfoot trefoil reached on average 93%, 166% and 90%, respectively. Nüesche (1960) studied persistence as a share of plants that survived two winters and found out that late varieties were more persistent than early varieties. Our results do not confirm this finding unambiguously, as the latest Czech variety Radegast demonstrated just average persistence.

Assessing the decrease of plants on our experimental plots, we found a positive correlation ($r = 0.85$) between the number of dead plants and the number of plants in the first year after sowing. Variances between the varieties equaled after the second wintering and no significant difference was found (Table 5). The most productive varieties (Lucrum, Spurt, Amos and Dolina) reached 71–93 plants per square meter. This abundance was sufficient for them to provide record yields.

Apart from genotype, the persistence of red clover stands is greatly influenced by the frequency of harvests. Sheldrick et al. (1986) inform that if the number of cuts was increased from three to six per year, they could observe not only a marked decrease of dry matter yield, metabolisable energy and crude protein yield per hectare, but at the same time a decreased persistence of plants. The persistence of plants also decreases if the plants bloom in the year of sowing (Choo 1984). Wiersma et al. (1998) reported that maximum persistence was achieved with cutting in the phenophase of 20–40% flowering heads and with 3 harvests per year. It is a similar stage as we used in our experiment.

Another factor that is likely to lead to limited persistence of red clover stands is referred to as 'clover soil sickness' or 'clover fatigue' (Katznelson 1972, Kjaergaard 1994). This factor causes impaired vital-

Table 5. Number of red clover plants in individual years (number/m^2) and number of lost plants between the 1st and 3rd harvest year

Variety	Red clover cover in June 2009 (%)	2007	2008*	2009	Number of lost plants 09–07
Astur	87.8^{a}	129^{abc}	92	78^{ab}	51^{ab}
SW Torun	78.0^{ab}	130^{abc}	78	76^{ab}	54^{ab}
Milvus	77.5^{ab}	110^{abc}	83	68^{ab}	42^{ab}
Lucrum	76.3^{ab}	170^{a}	93	97^{a}	73^{ab}
Amos	75.8^{ab}	117^{abc}	71	63^{ab}	54^{ab}
Start	75.3^{ab}	130^{abc}	85	83^{ab}	47^{ab}
Tedi	72.5^{ab}	110^{abc}	79	67^{ab}	43^{ab}
Gumpensteiner	69.0^{ab}	102^{bc}	68	67^{ab}	35^{a}
Nemaro	68.8^{ab}	124^{abc}	81	79^{ab}	45^{ab}
Veles	68.8^{ab}	94^{bc}	62	61^{ab}	33^{a}
Spurt	67.5^{ab}	142^{abc}	76	71^{ab}	71^{ab}
Radegast	67.3^{ab}	112^{abc}	74	71^{ab}	41^{a}
Dolina	67.0^{ab}	109^{bc}	77	74^{ab}	35^{a}
Pavo	66.5^{ab}	153^{ab}	77	56^{b}	97^{b}
Beskyd	63.8^{ab}	88^{c}	76	64^{ab}	24^{a}
Christie	58.8^{ab}	107^{bc}	77	69^{ab}	38^{a}
Vltavín	52.5^{ab}	141^{abc}	91	79^{ab}	62^{ab}
Endure	50.0^{ab}	121^{abc}	82	58^{ab}	63^{ab}
Betty	43.8^{ab}	119^{abc}	73	72^{ab}	47^{ab}
Jesper	41.3^{ab}	118^{abc}	76	70^{ab}	72^{ab}
Charlie	40.8^{ab}	108^{bc}	72	61^{ab}	47^{ab}
Reichersberger Neu	40.0^{b}	123^{abc}	54	50^{b}	73^{ab}
SE	4.36	2.91	1.74	1.77	2.64

* in 2008 no statistically significant differences were found; SE – standard error

ity of clover plants if they are repeatedly cultivated on one plot. Most often it is put into connection with nematodes, fungus *Sclerotinia trifoliorum* or with the exudation of allelopathic substances. We avoided these problems in our trial.

Marley et al. (2003) and Sheldrick et al. (1986) ascertained the persistence of red clover plants by counting the number of red clover plants within a quadrat of 0.15 × 0.15 m at nine random sites across each plot, which is an area smaller than we used in our trial. Sheldrick et al. (1986) found 108 plants/m^2 in pure clover stands in the first harvest year and only 37 in the third harvest year; the decrease in the number of plants was greater than in our trial. The reason for these differences may be further improvement of varieties and lower occurrence of pathogens in our experiment. Marley et al. (2003) recorded a higher number (120–138/m^2) in the second harvest year with Milvus variety.

A certain problem in assessing the persistence of red clover by the method of counting plants is the occurrence of hard seeds. Chmelař (1947) informs that the number of hard seeds, which would not germinate within 10 days after placement on germinator although they are viable, is normally 7–15% in red clover. Most of these seeds would germinate later in the same year but about 2.5% of hard seeds were found to germinate as late as 10 years after placement on seed germinator. Some of hard seeds (0.4%) germinated even after 25 years after placement on germinator. These plants can increase stand persistence only in thick, open canopy as they have no chance to establish in high yielding sward.

Although the persistence of clover stands is affected by a number of factors (see above), the significance of breeding is beyond dispute. In Wisconsin, a markedly improved persistence of new varieties was recorded. These new varieties are capable of giving satisfactory yields in the second production year, too. The survival of plants is over 60% and yields amount to more than 7.4 t/ha.

However, the degree coverage decreases in the red clover between the second and third production year by half (30% vs. 60%) (Wiesma et al. 1998). Similar results are presented in many other works (e.g. Lehmann and Briner 1998, Abberton and Marshall 2005, Taylor 2008).

The highest losses of plants are recorded in winter, the main cause of the decay of plants in western and northern Europe being infestation by fungus *Sclerotinia trifoliorum* and by nematodes (Sheldrick et al. 1986, Taylor and Queensberry 1996). In central Europe, the dieback of plants can be attributed namely to fungi from genus *Fusarium* and viruses – esp. BYMV, CMV and RCVM (Pokorný, R., personal communication). One of the most feared pests is field mouse (*Microtus arvalis*).

Distinct features of varieties

Effect of ploidity. Red clover cultivars are classified in two main ways: by the ploidity level and by the flowering date. Tetraploids are of larger size, contain more water and create larger inflorescences and seeds. These varieties are greatly used in Europe but have not found popularity in the USA (Taylor and Queensberry 1996, Abberton and Marshall 2005). Tetraploids were viewed in the past as more persistent and disease-resistant than diploid varieties but with new varieties this may not hold true (Frame et al. 1998).

Table 6 lists differences between diploid and tetraploid varieties of red clover used in our experiment. It was demonstrated that forage from tetraploid varieties contained significantly more water in both harvest years. Differences in persistence between the two groups expressed by the number of plants and cover percentage in the third production year were small and insignificant due to high variability within the groups (variation coefficient in diploids and tetraploids was 22.6% and 18.6%, respectively).

Effect of one-cut and two-cut types. In the collection of varieties studied in our experiment, three Swedish varieties SW Torun, Jesper and Betty of one-cut character markedly differed (Figure 1). They do not flower in the second cut and in the first cut they generate, on the average of both studied years, more than 75% of total annual yield. In contrast, Dolina, Pavo and Vltavín varieties reached the lowest share of the first cut in both years of the study (below 60%). These varieties would be preferably suitable for feeding green forage where balanced production is desirable during the growing period.

One-cut varieties are of major importance at sites in high latitude and altitudes where growing season is shorter and a larger part of total yield is therefore concentrated in the first cut (Haaling et al. 2004). One-cut varieties are not grown in the Czech Republic at present; a native variety registered in the past was Horal. Choo (1984) points out that all single cut varieties do not flower in the year of sowing. They are late in development, do not flower after the first cut in harvest years and give low yields in subsequent cuts.

The ratio between yields of the first growth and total annual yield is largely genetically affected. Some studies show that northern ecotypes of red clover have a greater response to photoperiod as compared with southern types, especially at lower temperatures (Lunnan 1989 in Haaling et al. 2004).

Other differences. SW Torun variety was regrowing considerably slower in spring than other varieties; Jesper variety exhibited slightly earlier regrowth. Betty and SW Torun varieties were the most susceptible to powdery mildew (*Erysiphe polygoni*) at the assessment made in the autumn in the year of sowing while Pavo and Charlie varieties did not show any signs of infestation. At later assessments, no great differences were found among the varieties.

Canadian varieties have conspicuously pubescent leaves and stalks. This is a common trait of North American varieties, which has developed as protection against insect pests. A disadvantage of trichomes is slower forage wilting and respiratory

Table 6. Differences in dry matter content in 2*n* and 4*n* varieties

	n	Dry matter in fresh herbage (g/kg)		Number of plants/m^2	Cover percentage
		2007	2008	2009	2009
Diploids	14	250	187	69.6	61.2
Tetraploids	8	226	174	69.9	69.0
Differences		24*	13*	0.3^{ns}	8.8^{ns}

problems of both animals and humans at handling hay. This is why varieties with lower intensity of pubescence are being chosen in the USA today (Taylor 2008).

Economic conditions of cattle farms have been changing recently in consequence of pressures to reduce the consumption of energy, mineral fertilizers, to mitigate environmental pollution, to increase the sustainability of agricultural systems and to enhance biodiversity. All this speaks for increased use of legumes (Rochon et al. 2004). A promising achievement in increasing red clover persistence is the discovery of plants creating stolons that are allegedly more persistent than common types (Smith and Bishop 1993). Although there are new leguminous species bred such as *Trifolium ambiguum*, the red clover will remain the main clover crop in most forage-cultivating regions of temperate zone worldwide with respect to the outstanding quality of its forage, rapid development after sowing, easy stand establishment and high competitiveness.

The comparison of our experimental results with older works shows that a great progress occurred in the last 40 years in breeding red clover varieties for persistence.

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