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The effect of perennials as green manure on cereal productivity and disease incidence

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Abstract

Field experiments were conducted at the Vezaiciai Branch of the Lithuanian Research Centre for Agriculture and Forestry during the period 2002-2007. They were designed to ascertain the effects of phytomass of different perennial pre-crops used for green manure on the productivity and on the occurrence of foliar fungal diseases of cereal agrocenoses. Plant residues and phytomass ploughed down as green manures positively affected cereal indices of crop productivity not only for the first but for the second year as well. It influenced the productivity of cereal segments. The largest amount of metabolizable energy was in the yield of cereal sequence under white clover (*Trifolium repens* L.) —83.23-84.76% GJ ha^{-1}. The potential accumulated by perennials of the second year of development was more efficiently utilised by winter triticale (*Triticosecale* Wittm.) cv. 'Tevo', and that of perennials of the third year of development was more efficiently utilised by spring barley (*Hordeum vulgare* L.) cv. 'Ula'. Perennials had a significant effect on the spread of foliar diseases in winter triticale (*Triticosecale* Wittm.) and spring barley (*Hordeum vulgare* L.) agrocenoses. The severity of the disease was 1.1-1.3 times higher in the winter triticale (*Triticosecale* Wittm.) treatments with white clover (*Trifolium repens* L.) pre-crops. Foliar disease incidence and severity was 1.1-1.2 times higher in the agrocenoses of spring barley (*Hordeum vulgare* L.) after legumes of the third year of development, especially after lucerne (*Medicago sativa* L.).

Additional key words: nutrients; phytomass; spring barley; winter triticale; yield.

Resumen

Efecto de las plantas perennes como abono verde en la productividad y en la incidencia de enfermedades de los cereales

Se determinó el efecto de añadir, como abono verde, fitomasa de diferentes plantas perennes cultivadas previamente, sobre la productividad y la aparición de enfermedades foliares fúngicas en agrocenosis de cereales. Para ello se llevaron a cabo experimentos de campo en el Centro Lituano de Agricultura y Bosques durante el período 2002-2007. Los residuos de las plantas y la fitomasa añadidas como abono verde afectaron favorablemente a los índices de productividad de los cereales, tanto para el primer año como para el segundo. Esto influyó en la productividad de los segmentos de los cereales. La mayor cantidad de energía metabolizable fue en el rendimiento de la secuencia de cereales precedidos por trébol blanco —83,23-84,76% GJ ha^{-1}. El potencial acumulado por las plantas perennes durante el segundo año de desarrollo fue utilizado más eficientemente por el triticale de invierno cv. Tevo, y el de los pastos del tercer año por la cebada de primavera cv. Ula. Las plantas perennes tuvieron un efecto significativo sobre la propagación de enfermedades foliares en las agrocenosis del triticale de invierno y de la cebada de primavera. La gravedad de la enfermedad fue 1,1-1,3 veces mayor en los tratamientos del triticale con trébol blanco como cultivo previo. En la agrocenosis de la cebada de primavera, la incidencia y gravedad de las enfermedades foliares fue de 1,1 a 1,2 veces mayor después del uso de diferentes leguminosas en el tercer año de desarrollo, especialmente después de la alfalfa.

Palabras clave adicionales: cebada de primavera; fitomasa; nutrientes; rendimiento; triticale de invierno.

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Introduction

Nowadays, one of the challenges for sustainability in agricultural practices is to develop a widely applicable scheme with measures to maintain or increase soil quality and decrease nutrient losses from grass-arable rotations under different conditions, using the results of studies in different countries. An increased risk of losses due to the polarization of fields requires new solutions for finding the best ley-arable rotations to meet several objectives: preserve soil quality and production potential, minimize N and C losses and environmental impacts, optimize nutrients and energy input efficiency, and preserve landscapes and biodiversity. System analyses are needed to evaluate the agronomic and environmental consequences of the type of arable crop in grass-arable rotations and to optimize all components of sustainable agriculture (Vertès *et al.,* 2007).

The productivity of arable crops in organic farming is restricted by the supply of N (Askegaard *et al.*, 2005; Olesen *et al.*, 2007). Biological N fixation is one of the primary sources of N in organic farming. Forage and grain legumes, especially clover, must be used in organic crop rotations as a soil fertility increasing component (Berry *et al.*, 2002).

Seeking to achieve a balanced functioning of agrocenoses, it is vital to maintain a high productivity level of crops grown using organic management practices, whose major problem is yield losses to diseases.

The spread of diseases has become an increasingly worrying issue on "environment-friendly" farms. As a result, any attempts to generate novel scientific information on disease distribution and management issues should be heeded and positively encouraged. Many authors indicate that the incidence of fungal diseases of cereals is determined by the weather conditions, imbalanced mineral fertilisation, crop species and variety, soil preparation, sowing time, preceding crop, weed infestation, abundance of pests, and luxuriance of the crop stand (Bailey & Duczek, 1996; Dreiseitl, 2007). More abundant mineral fertilisation of winter cereals in some cases slows down the spread of *Septoria*, but sometimes has virtually no effect. Some researchers' data suggest that more abundant fertilisation promotes the spread of cereal diseases too (Bailey & Duczek*,* 1996; Conway, 1996; Eyal, 1999). However, experimental results often vary considerably between years. It is maintained that preceding crops of winter cereals have quite a weighty effect on the occurrence of root rots, however, there is little experimental evidence on the effects of this factor on the spread of foliar diseases (Lõiveke *et al.*, 2003; Lõiveke & Sepp, 2009). Research on the use of various herbaceous species for green manure in contemporary agriculture has gained new relevance. Cheap and high quality green manure is an important element in crop alternation in specialised cereal crop rotations.

In Lithuania, soils of agricultural land markedly differ in productivity. Nearly 40% of the soil is insufficiently fertile (Tripolskaja & Sidlauskas, 2010), moreover, those in the western part of the country are characterised by an acid reaction (Repsiene & Skuodiene, 2010). Recently, Lithuania has been subject to traditional crop, such as winter oilseed rape and cereals, and perennials are ignored. Soil degradation is observed especially in the Western part of Lithuania. All these reasons hamper the formation of food, water and warmth regime for the best usage of genotype potential in the soil. The improvement and conservation of this soil fertility are the strategic directions of agriculture of Lithuania. It is important to keep nutrient reserves in the soil with organic matter (Ozeraitiene, 2002).

Generalization of data of researches carried out in various countries suggests that perennials are an excellent green manure in environmentally unstable and infertile soils. It is proved that green manure improves agrochemical properties of soil and increases its nutrient content which is necessary for plants. However, in many cases, there is a disagreement on what type of perennials are the most promising in this regard. It is credible that different amount of perennials, that differ in their chemical composition, forms irregular nutritional conditions for cereals. This may cause phytopathological state of crops. The current study was aimed to explore the effects of phytomass of perennials used as green manure on cereal nutrition conditions in a crop rotation productivity and incidence of foliar disease of cereals.

Material and methods

Site description

The field experiments were conducted in Western Lithuania at the Vezaiciai Branch of the Lithuanian Research Centre for Agriculture and Forestry (55°43'24 N, 21°27'24 E) in 2002-2007. Two analogous experiments were set up in 2002 and 2003. The field experiments were conducted using a multi-factorial method. The experimental treatments were replicated four times and were arranged randomly. The soil of the experimental site was albi — edohypogleyic luvisol, light loam on medium heavy loam. The ploughlayer's agrochemical characteristics were as follows: pH_{KCl} – 6.0-6.1; mobile P_2O_5 and K_2O – 104-199 and 120-166 mg kg^{-1} soil, respectively; N_{total} 0.08-0.11%; C_{org} 0.90-1.05%.

Experimental design

The experiments were conducted in the following crop rotation sequence: perennials — winter triticale (*Triticosecale* Wittm.) cv. 'Tevo' — spring barley (*Hordeum vulgare* L.) cv. 'Ula'. Perennials included: red clover (*Trifolium pratense* L.) cv. 'Vyliai', white clover (*Trifolium repens* L.) cv. 'Suduviai', lucerne (*Medicago sativa* L.) cv. 'Birute' and timothy (*Phleum pratense* L.) cv. 'Gintaras II'.

The swards were different not only in age but also in the application. The territory of the experiment was divided into two plots. Perennials were grown in the first plot for two years. First year was the perennials sowing year. In the second year of development of perennials 1st crop of perennials was used for forage, second crop for green manure: 1) only residues ploughed-in and overground phytomass removed from field (R); 2) overground and underground phytomass ploughed-in (R + A). Perennials were grown for three years in the second plot. First year was the perennials sowing year. In the second year of development of perennials there were three cuts, at the third year of development of perennials 1st crop of perennials was used for forage, second crop for green manure: 1) R; 2) R + A) (Table 1). Timothy grass was chosen for a control treatment. Timothy grass adapts to Lithuania's natural conditions best. It is resistant to winter cold and can be grown in the acid soil (Daugeliene, 2002).

The phytomass was chopped and shallowly incorporated during beginning of flowering of legumes and beginning of ear emergence of timothy after two weeks deeply ploughed in 25 cm. No mineral fertilisers and plant protection products were used in order to determine the biological value of different preceding crops.

Plant and soil analyses

Plant residue mass was determined by the Katchinski monolith washing method (Lapinskiene, 1986). It was considered the following as plant residues: stubble

Table 1. Scheme of management methods of perennials

Perennials and abbreviation of treatment[1]	Management methods of perennials	
	Second year of development of perennials	Third year of development of perennials
Timothy (II, R)–Control	2 cuts, ploughed-in only residues	—
Timothy (III, R)	3 cuts	Cut twice, ploughed-in only residues
Lucerne (III, R+A)	3 cuts	1st crop for forage, ploughed-in overground and underground phytomass
Lucerne (III, R)	3 cuts	Cut twice, ploughed-in only residues
Red clover (II, R+A)	1st crop for forage, ploughed-in overground and underground phytomass	—
Red clover (II, R)	2 cuts, ploughed-in only residues	—
Red clover (III, R+A)	3 cuts	1st crop for forage, ploughed-in overground and underground phytomass
White clover (II, R+A)	1st crop for forage, ploughed-in overground and underground phytomass	—
White clover (II, R)	2 cuts, ploughed-in only residues	—
White clover (III, R+A)	3 cuts	1st crop for forage, ploughed-in overground and underground phytomass

[1] R: ploughed-in only residues, R+A: ploughed-in overground and underground phytomass. II: second year of development of perennials, III: third year of development of perennials.

and roots situated at the 25 cm depth. The mass of all plant residues and overground mass were re-calculated into dry matter. Having determined the concentration of major nutrients the content of nutrients (kg ha^{-1}) incorporated into the soil was calculated. The content of phosphorus in the green material of preceding crops, their plant residues and cereal grain and straw was determined by colorimetry and potassium by flame photometry methods (Faithful, 2002).

Number of productive stems of cereals were established in each treatment (replicated four times), in two places of 0.25 m^{-2} in size. Grain samples for analyses were taken from each treatment after pre-cleaning. The data on yield were adjusted to 15% moisture content.

To estimate cereal yield, the accumulated metabolisable energy content was calculated, *i.e.* grain and straw yield expressed in dry matter was multiplied by ME content per kilogram of dry matter (Jankauskas *et al.*, 2000). Metabolisable energy of triticale was calculated using the coefficients of wheat metabolisable energy.

Soil samples were collected before trial establishment and after perennials ploughing in from the 0-20 cm depth. Available P_2O_5 and K_2O were determined by the A-L method, total nitrogen by Kjeldahl, organic carbon by a mineraliser 'Heraeus'.

Disease assessments

Foliar disease assessments on winter triticale were carried out in 2004-2006 in the third ten-day period of June at late milk maturity stage (BBCH 77-80). Foliar disease assessments on spring barley were carried out in 2005-2007 at stooling stage (BBCH 37-39) and at milk maturity stage (BBCH 73-75). For averaging, 50 sample plants were collected from ten locations on every plot, on every variant by diagonals, 4 average samples. The following methods were used for the diagnostics of foliar fungal diseases: visual, according to external symptoms and microscopy.

To assess foliar diseases EPPO guidelines were used, for Septoria leaf blotch, brown rust and scald (EPPO/OEPP 1984, No.79), for net blotch and spot blotch (PP 1/29(2)).

Climatic conditions

Western regions of Lithuania are strongly affected by the maritime climate (in winter it is warmer and in summer it is cooler than in eastern regions). The soil is more podzolized and acid than in the other regions. It receives the highest rate of precipitation, which has amounted to an average of 862 mm annually during the last 10 years. Weather data were acquired from the local automatic weather station located in immediate proximity (400-500 mm) of trials. Weather conditions during separate years differed considerably, and this affected not only the development of perennials but also organic matter breakdown intensity and formation of cereal yield biological parameters, disease occurrence (Table 2).

Data analysis

The experimental data were processed by ANOVA and correlation-regression analysis methods (Clewer & Scarisbrick, 2001).

Results and discussion

Dry matter yield and chemical composition of perennials designed to be used as green manure

The dry matter yield of perennials grown under conditions of the Western Lithuania in ecologically sensitive soils depended on grass species, age, fresh and dry matter yield, and management method. Significantly higher

Table 2. Climatic characteristics of the experimental years

Year	2002	2003	2004	2005	2006	2007
Annual mean air temperature (°C)	7.8	7.0	7.0	7.0	7.5	7.9
Deviation from long-term mean 1947-2007 (°C)	+ 1.1	+ 0.3	+ 0.3	+ 0.3	+ 0.8	+ 1.1
Annual precipitation totals (mm)	865.0	767.8	904.1	990.5	675.6	1,244.3
Annual precipitation totals as percentage of the long-term mean 1947-2007 (%)	102.5	91.2	107.2	117.2	80.2	146.5

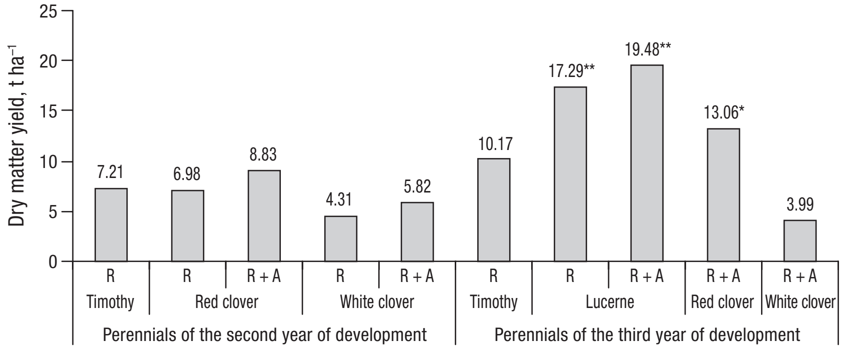

Figure 1. Dry matter yield of phytomass of perennials. For abbreviations see Table 1. * significant at $p < 0.05$, and ** significant at $p < 0.01$.

phytomass dry matter content was left in the soil by lucerne (17.29 and 19.48 t ha^{-1}) and red clover of the third year of development (13.06 t ha^{-1}) (Fig. 1).

Nutrient content accumulated in plants depends on species (Tekeli & Ateş, 2005) and growth stage (Cassida *et al.*, 2000). The highest concentrations of nitrogen, phosphorus and potassium were determined in the above-ground part of white clover in the second year of development, though the amount of phytomass incorporated was not the highest (Table 3). It is noteworthy that white clover herbage accumulated the highest phosphorus content during the third year as well. This research confirms the benefits of white clover as green manure for acid soil fertilization, which is especially relevant to organic farms, where neither farmyard manure or any other green manure can adequately solve phosphorus shortage issues. The highest nitrogen concentration was found in the above-ground part of lucerne in the herbage of grasses in the third year of development, while highest potassium concentration was found in the above-ground part of red clover.

Much lower nutrient contents accumulated in the under-ground part of perennial legumes in the second year of development: N 1.4-1.6, P 2.2-4.0 and K 2.1-3.6 times less, and in the herbage in the third year of development: N 1.1-2.1, P 1.2-1.7 and K 1.6-2.1 times less, in comparison with nutrient contents in above-ground part. However, the highest content of phosphorus was identified in the under-ground part of white and red clover in the third year of development. The under-ground part of legumes was richer in nitrogen in the second year of development, however, the differences between red and white clover were negligible.

Phytomass quality is important for the control of the content and availability of nitrogen, obtained from plant residues. This is defined by the C:N ratio (Trinsoutrot *et al.*, 2000; Personeni & Loiseau, 2004). The C:N ratio is one of the many factors determining organic matter transformation processes in the soil. The C:N ratio differed between legume and grass species as well as in their aboveground and underground phytomass. For all

Table 3. Chemical composition of the phytomass of perennials intended for green manure. Average data of 2003-2005

Perennials	Plant overground phytomass				Plant underground phytomass			
	Amount of nutrients, %			C:N	Amount of nutrients, %			C:N
	N	P_2O_5	K_2O		N	P_2O_5	K_2O	
Herbs of the second year of development								
Timothy	1.10	0.37	1.83	26	0.74	0.15	0.57	33
Red clover	2.41	0.57	2.32	12	1.75	0.26	1.12	20
White clover	2.80	0.76	2.95	14	1.69	0.19	0.82	21
Herbs of the third year of development								
Timothy	0.98	0.48	1.36	23	0.90	0.33	0.67	36
Red clover	1.98	0.48	2.18	14	1.65	0.41	1.03	22
White clover	1.78	0.60	1.57	14	1.48	0.41	0.98	24
Lucerne	2.38	0.54	1.46	10	1.14	0.32	0.83	27

Table 4. Correlation matrix for dry matter yield and amount of nutrients

Characters	Dry matter yield	N	P_2O_5	K_2O
Dry matter yield	1			
N	0.906**	1		
P_2O_5	0.926**	0.980**	1	
K_2O	0.893**	0.985**	0.982**	1

**significant at $p < 0.01$.

plants tested, the C:N ratio was established to be lower in the above-ground phytomass compared with that of the under-ground phytomass (Table 3). The C:N ratio of lucerne and both clover species was similar, however, much lower than that of timothy. The higher C:N for timothy was determined by a low nitrogen content in its phytomass. This explains the lower N mineralization under grass (Elgersma & Hassink, 1997).

The C:N ratio differed little according to plant development age. Literature sources indicate that the age of grassland has only a weak effect on yearly inputs, but affects macro-organic matter accumulation by humification and detritic pathways (Vertès *et al.*, 2007).

The amount of nutrients incorporated into the soil with the phytomass

Significant positive correlations were found between dry yield and the amount of nutrients incorporated into the soil with phytomass of perennials (Table 4).

Like in other research carried out in Lithuania on the soils of various genesis (Arlauskiene & Maiksteniene, 2004), our study conducted on acid soil shows that lucerne produced significantly higher phytomass yield and left the highest nutrient contents in the soil (Fig. 2). After ploughing in the phytomass of lucerne, the soil received 303.6 kg ha^{-1} of N, 74.0 kg ha^{-1} of P and 199.9 kg ha^{-1} of K, which is: 1.2-2.5 times more than after red clover, 2.1-5.2 times more than after white clover and 2.1-5.0 times more than after timothy. Although the differences in the amount of green manure crops' phytomass and chemical composition influenced the different amounts of nutrients incorporated into the soil and the N: P_2O_5: K_2O ratio remained similar*, i.e.* 1 kg : 0.2-0.4 kg : 0.6-0.8 kg.

The effect of perennials on cereal productivity

The literature suggests that during mineralisation of nitrogen-rich legume residues, gradually released nitrogen positively affects the formation of productivity elements during all growth stages of cereals, unlike mineral fertilizers, whose large part is leached (McGuire *et al.,* 1999). Winter triticale produced the highest yield when grown after white clover of the second year of development (Table 5). It is assumed, that this depended on the chemical composition of white clover phytomass, since the ratio of nutrients (NPK) getting into the soil with this phytomass is lower, compared with red clover and even lucerne phytomass.

Spring barley was grown in the second year due to the effect of the management practices applied. Significant impact on productive stem number of barley and grain yield was exerted by the ploughed in perennials of the third year of development, especially lucerne.

Some researchers maintain that the decomposition of dead plant material has to be rapid so that it contains

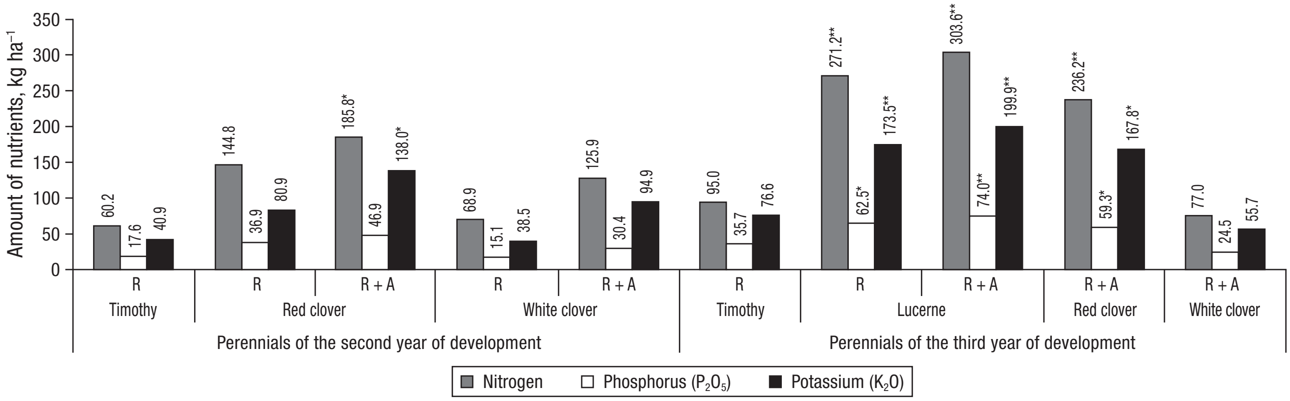

Figure 2. Amount of nutrients incorporated into soil with phytomass of perennials. For abbreviations see Table 1. * significant at $p < 0.05$, and ** significant at $p < 0.01$.

Table 5. Effect of perennials as preceding crop on the yield-forming indicators and the amount of metabolizable energy of cereals. Average data of 2005-2007

Perennials[1]	Yield-forming indicators: Number of productivity stems, units m^{-2}		Yield-forming indicators: Grain yield t ha^{-1}		Metabolizable energy of cereals, GJ ha^{-1}		
	Winter triticale	Spring barley	Winter triticale	Spring barley	Winter triticale	Spring barley	Total
Timothy (II, R)–Control	320.0	300.5	2.07	1.44	41.34	26.71	68.05
Timothy (III, R)	221.0	323.5	2.00	1.55	34.00	30.44	64.44
Lucerne (III, R+A)	252.0	376.5*	2.85**	1.80**	47.15	34.98**	82.13*
Lucerne (III, R)	244.0	369.0*	2.52	1.64	44.41	31.63*	76.04
Red clover (II, R+A)	334.2	325.8	2.79*	1.51	52.81**	26.79	79.60*
Red clover (II, R)	325.2	316.5	2.78*	1.49	52.64**	28.26	80.90*
Red clover (III, R+A)	218.2	369.5*	2.01	1.58	36.26	32.18*	68.44
White clover (II, R+A)	310.2	296.2	3.13**	1.47	57.33**	27.43	84.76**
White clover (II, R)	323.0	339.0	2.94**	1.35	55.85**	27.38	83.23**
White clover (III, R+A)	216.0	357.2	2.22	1.60	28.68	31.30*	69.98
LSD_{05}	51.612	64.746	0.549	0.267	7.501	4.123	5.479

[1] For abbreviations see Table 1. * significant at $p < 0.05$, and ** significant at $p < 0.01$.

1.5-2.0% of nitrogen, which is necessary for heterotrophic microorganisms that break down organic matter (Rimkus, 2003). Of all perennials tested, only red clover roots contain a sufficient amount of nitrogen (1.65%) for more rapid mineralisation, white clover roots contain less nitrogen (1.48%). Since timothy phytomass low in nitrogen mineralised very slowly, cereal productivity formation indicators were the poorest. It can be maintained that slower lucerne residue mineralization had a positive effect on winter cereal grain yield. Perennials as cereal pre-crops exerted a significant effect on winter triticale and spring barley metabolisable energy content, respectively: $F_{fact.}=10.00>F_{theor.0.1}=2.70$ and $F_{fact.}=3.70>F_{theor.0.1}=2.70$. In cereal sequence, significantly highest metabolisable energy content over two years was accumulated after white clover in the second year of development (83.23-84.76 GJ ha^{-1}). In cereal sequence, the highest metabolisable energy content was accumulated by winter triticale — from 52.8% to 67.6% of the total content (Table 5). Comparison of the perennials as cereal pre-crops revealed that the potential accumulated by perennials of the second year of development was more efficiently utilised by winter triticale, and that of grasses of the third year of development by spring barley.

According to average data of metabolisable energy the efficacy of perennials used as green manure ranked as follows: white clover > lucerne > red clover > timothy. In most cases this was determined by the productivity increase of the first member of the sequence after perennials incorporation.

Foliar disease incidence and severity in cereals

One of the major factors affecting cereal productivity is disease infestation. Winter triticale has a higher resistance to fungal diseases than other cereals. Although winter triticale tends to show a high degree of resistance to fungal diseases, some important diseases still have been observed on this crop and may cause serious economic damage (Conway, 1996). During the experimental period the leaves of winter triticale were affected by 10 species of fungal diseases causal agents. But only three species: scald (causal agent *Rhynchosporium secalis* (Oudem.) J. Davis), brown rust (causal agent *Puccinia recondita* Roberge ex Desmaz.) and septoria leaf blotch (causal agent *Septoria tritici* Roberge ex Desmaz.) showed more intensive incidence.

The growing conditions of host-plants in some cases influenced the incidence of scald: 1.2-1.3 times lower incidence of this disease was recorded on the winter triticale that had been grown after red clover of the second year of development, whose residue and phytomass were incorporated and after timothy whose only residue had been incorporated, compared with the incidence of this disease on winter triticale grown after perennials managed by other methods. Winter triticale grown after perennials of the third year of development was affected by scald at a very similar level: slightly more than 20% (Fig. 3). In most cases, significant differences were recorded for scald severity. Disease severity of 5% and lower was determined on winter

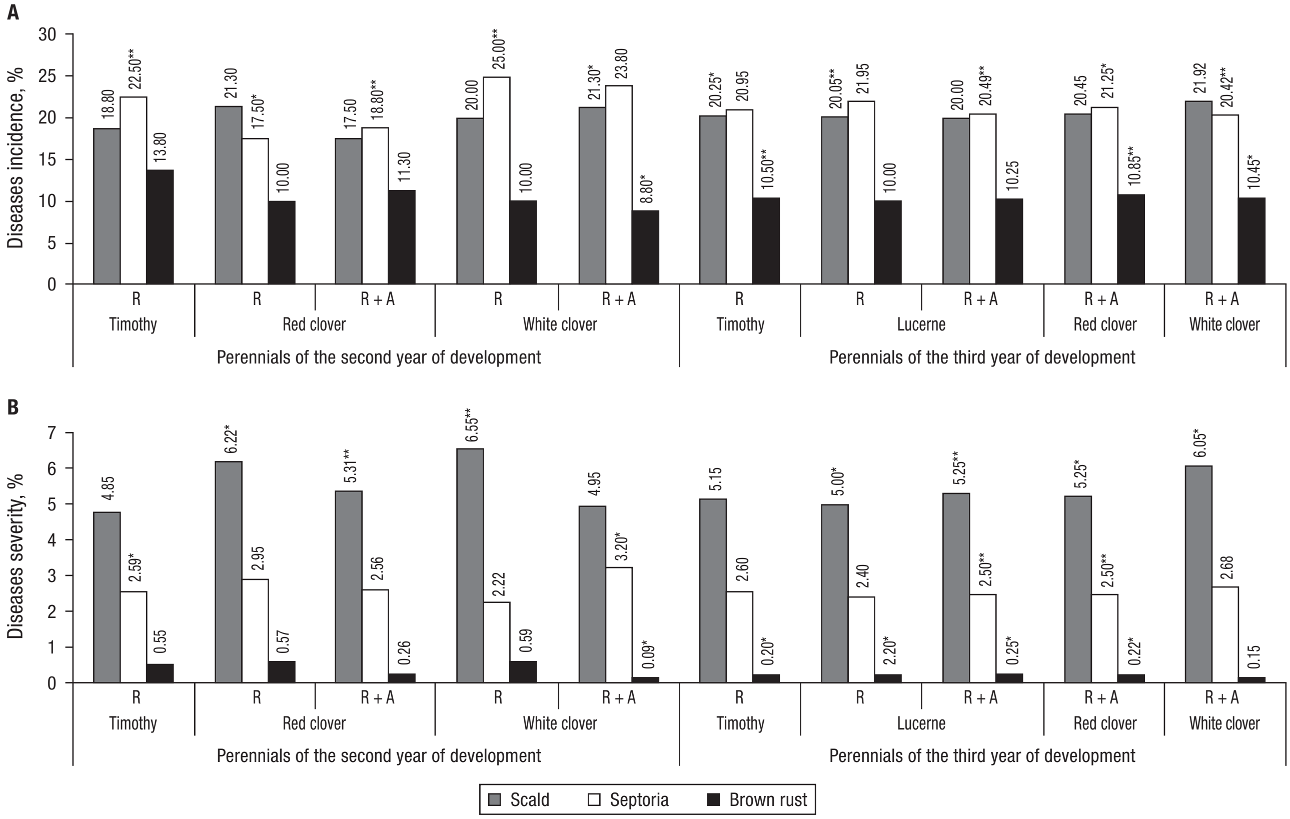

Figure 3. Influence of preceding crops (perennials) on the first year grown winter triticale foliar diseases incidence (A) and severity (B). Average data of 2004-2006. For abbreviations see Table 1. * significant at $p < 0.05$, and ** significant at $p < 0.01$.

triticale, whose pre-crops were: white clover of the second year of development and timothy and lucerne of the third year of development whose only residue had been incorporated. However, scald severity on winter triticale grown after red and white clover of the second year of development whose only residue had been incorporated, also after white clover of the third year of development exceeded 6% (Fig. 3). Septoria incidence was 1.1-1.4 times lower on winter triticale grown after red clover of the second year of development compared with its incidence on winter triticale grown after perennials of other species of the same year of development. The lowest brown rust incidence was determined on winter triticale grown after white clover and after lucerne, compared with winter triticale grown after other pre-crops. Inappreciably higher brown rust incidence was identified on winter triticale grown after perennials of the second year of development (Fig. 3).

The incidence and severity of winter triticale disease were significantly affected by plant population density. Higher incidence of major disease affecting cereals as well as disease severity were recorded in the crops with a higher population density (*r* from 0.492* to 0.955*). It can be maintained that disease incidence in most cases is influenced not directly by pre-crops due to which the soil is enriched with nutrients and soil texture is improved, but diseases tend to occur most intensively where the conditions for the propagation of disease causal agents are most conducive, *i.e.* in denser crops, and crop density increases with optimised crop and soil management practices and pre-crops that improve cereal productivity indicators.

Net blotch (causal agent *Drechslera teres* (Sacc.) Shoem., teleomorphic stage: *Pyrenophora teres* Drechs., (syn. *Helminthosporium teres* Sacc.) and spot blotch (causal agent *Drechslera sorokiniana* (Sacc.) Subram.) occurred most severely in spring barley during the growing season. Averaged data suggest that at spring barley stooling stage (BBCH 37-39) net blotch incidence was 1.1-1.2 times higher on the cereal crops that had been grown after different perennials of the third year of development (Fig. 4). In all agrocenoses, the highest net blotch incidence (from 92.35 to 97.50%) was recorded on spring barley grown after lucerne, compared with its

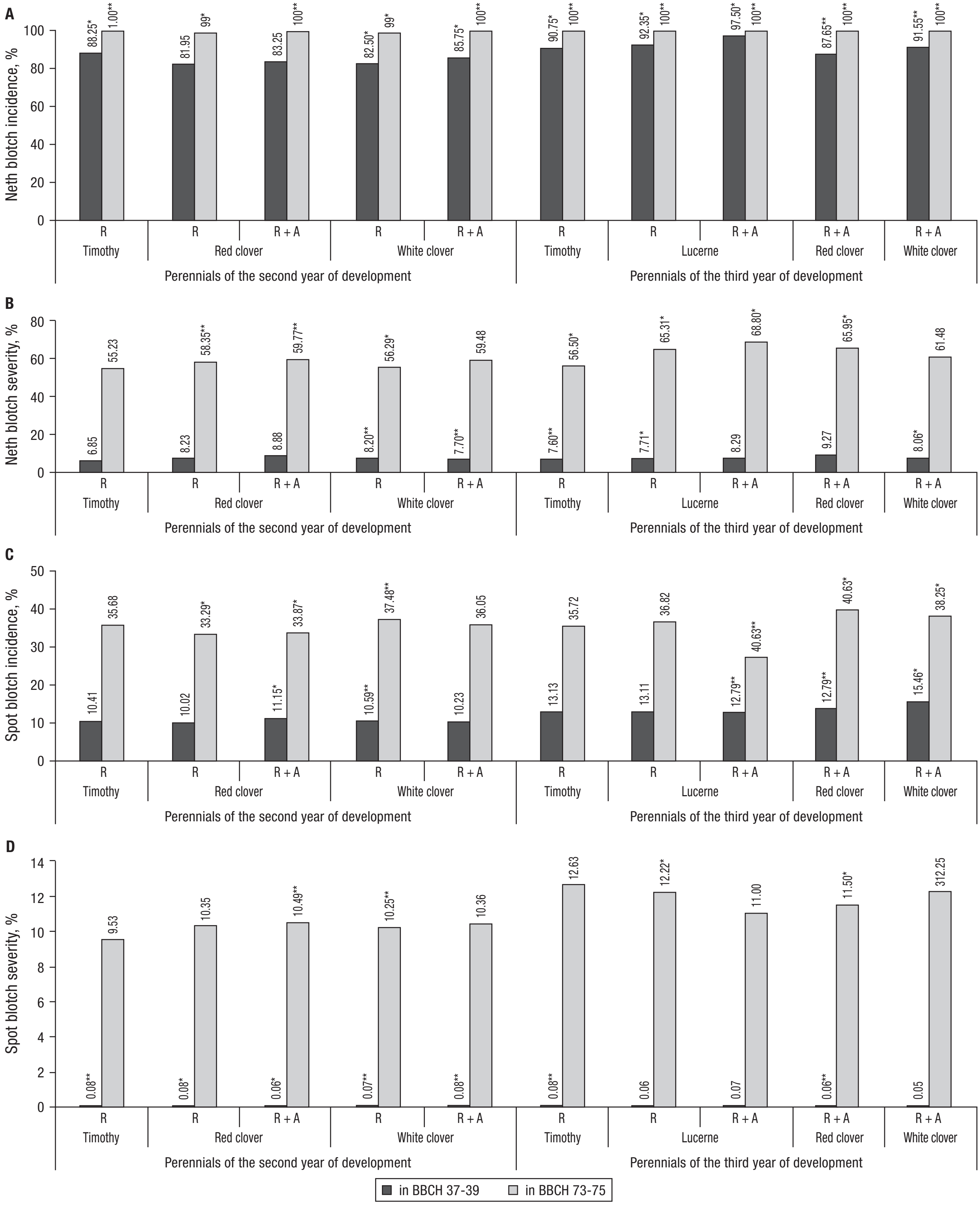

Figure 4. Influence of preceding crops (perennials) on the second year grown spring barley neth blotch and spot blotch incidence (A, C) and severity (B, D). Average data of 2005-2007. For abbreviations see Table 1. * significant at $p < 0.05$, and ** significant at $p < 0.01$.

incidence on spring barley grown after other species of perennials. Nearly 100% of spring barley in all treatments was affected by net blotch at milk maturity stage (BBCH 73-75); 1.1-1.2 times higher net blotch severity was recorded on spring barley grown after red and white clover of the third year of development, and especially after lucerne. Research carried out in south Lithuania has shown that with increased nitrogen fertiliser incorporation into the soil the severity of net blotch tends to increase (Braziene & Dabkevicius, 2002). While in Estonia, research done under similar conditions gave opposite results: 1.2 times lower net blotch incidence was recorded on spring barley grown in the soil heavily fertilised with organic fertilisers in the autumn, compared with the disease severity on spring barley without any fertilisation (Lõiveke & Sepp, 2009).

Spot blotch was more severe on the crop, grown after perennials of the third year of development. The highest spot blotch incidence was recorded on spring barley grown after white and red clover as well as after lucerne (Fig. 4). This trend persisted in spring barley crop at milk maturity stage (BBCH 73-75): in the mentioned treatments spot blotch incidence was 1.1-1.2 times higher compared with its incidence on spring barley grown after other species of perennials. This suggests that spot blotch, like net blotch, is more likely to occur on spring barley growing in the soil with a higher nutrient status. As it was mentioned earlier, this could be linked to higher density of host-plants and from this resulting in more favourable conditions for fungal disease development. Moderately strong direct correlation was established between spot blotch incidence and severity and number of productivity stems of spring barley (r = 0.488* and 0.520**, respectively).

Up till now researches in Lithuania and neighbour countries have generally recommended red clover as green manure (among perennials used in this research). The maximum grain yield of different cereals was always obtained after red clover as preceding crop. This study showed that, for a rapid effect of green manure it is the most effective to use white clover as preceding crop, and long-term effect is obtained when the lucerne is grown as green manure. Perennials of the third year of development determined more favourable soil conditions for the development of spring barley. The highest accumulated content of metabolisable energy suggests that the potential of perennials of the second year of development was best exploited by winter triticale and that of grasses of the third year of development best exploited by spring barley. But in cereals preceded by white clover and lucerne we identified a more intensive occurrence of some diseases, compared with other preceding crops (diseases spread more intensively in dense stand). However, when the spread of diseases is not very intensive, it does not reduce the grain yield of cereals. It seems likely that the yield will be even greater when plant protection measures are used.

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