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Dependence of crop residues decomposing in soil on their chemical composition and environmental conditions

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Decomposition of crop residues was studied at the Experimental Station of the Lithuanian University of Agriculture in a model field experiment in the period 2003–2005. The soil of the experimental site is drained moraine loamy *Endocalcari-Epihypogleyic Cambisol* (*sicco*). The aim of the investigation was to establish the decomposition intensity of oilseed rape residues in soil and its dependence on residue chemical composition and environmental conditions in comparison with wheat and clover residues.

During 26.5 months of crop residue decomposition in soil and a decrease of dry matter and organic carbon content, the C : N ratio was also decreasing. The concentration of lignin in decomposing crop residues was relatively increasing during the first 14.5 months. After 19.5 months, in all crop residues the concentration of lignin was lower, but a significant decrease was found after 26.5 months of their incubation in soil.

The most intensive decomposition of oilseed rape threshing remains (winter rape 24.4 and spring rape 23.6% mth^{-1}), stubble of wheat (22.1% mth^{-1}) and clover (23.4% mth^{-1}) was recorded during the first three months of incubation in soil. The stubble of winter and spring oilseed rape decomposed slower: during warm periods the intensity of decomposition was 2.6–6.0 and 5.6–8.4% mth^{-1}, respectively. Wheat and clover roots decomposed most intensively during the first (both 8.2% mth^{-1}) and second (respectively 6.7 and 8.1% mth^{-1}) warm periods and oilseed rape roots during the second (w. rape 4.3, s. rape 9.1% mth^{-1}) and third (w. rape 3.8% mth^{-1}) warm periods.

After 26.5 months, the stubble of winter and spring oilseed rape was decomposed less (respectively 68 and 77%) than their threshing remains (both 93%), the stubble of wheat (86%) and clover (95%). Winter oilseed rape roots were decomposed significantly less (59%) than roots of spring oilseed rape (75%), wheat (80%) and clover (82%).

The correlation between dry matter content and C : N ratio in oilseed rape stubble and the roots of oilseed rape, winter wheat and red clover was strong positive (r = 0.93**–0.97**), while in other residues it was weaker (r = 0.74**–0.84**). In terraneous residues of oilseed rape, the content of dry matter strongly correlated with the content of lignin (r = from –0.78** to –0.87**). In the stubble of winter wheat and red clover, the correlation between these indices was modest – respectively r = –0.52** and r = –0.64**. In spring oilseed rape roots, the correlation between the content of dry matter and lignin was very strong (r = –0.93**), in the roots of winter oilseed rape (r = 0.86**) and wheat (r = 0.85**) strong, and in clover roots there were no correlation between these indices.

The temperature of air and soil, the sum of these temperatures (≥5 °C) and precipitation had a stronger influence on crop residue decomposition per period than on their decomposition intensity per month. In rape stubble, the correlation between these agrometeorological indices and decomposition intensity during the period (r = 0.89**–0.98**) and per month (r = 0.50*–0.94**) was stronger than in their threshing remains(r = 0.48*–0.78**) and wheat or clover stubble (r = 0.45*–0.85**). Decomposition intensity of winter rape roots per month depended on agrometeorological conditions (r = 0.80**–0.85**) more than did other residues (r = 0.57**–0.80**). Decomposition of rape roots per period was influenced mostly by precipitation (winter rape r = 0.94**, spring rape r = 0.71**), while decomposition of wheat and clover roots by temperature (r = 0.84**–0.92**).

Key words: winter and spring oilseed rape, winter wheat, red clover residues, C : N, lignin, temperature, precipitation, correlation

INTRODUCTION

The stability of soil fertility is determined by the decomposition of organic matter covering mineralization, humification, fixation and migration (Александрова, 1980). The decomposition of freshly introduced organic matter depends first of all on the matter sort, age, particle size, nitrogen content and C : N ratio in it (Švedas, 2001; Janušienė, 2002; Slepetiene et al., 2005;

Tripolskaja, 2005). The humidity, temperature, aeration, pH, amount of nutrients of the soil also influence the intensity of decomposition of both organic matter and soil organic matter (Wolf, Snyder, 2003). Depending on humidity, organic matter decomposition can proceed under aerobic and anaerobic conditions. The decomposition is more intensive at a soil temperature of 30 °C and at a humidity of 60–80% from the total moisture retention capacity of soil. Humidity surplus and thus the lack of oxygen slow down the activity of microorganisms and organic matter decomposition and change the processes of decomposition in the direction of humification. So, in waterlogged soils more humic substances accumulate (Wolf, Snyder, 2003; Tripolskaja, 2005).

According to M. M. Kononova (1963), the decomposition of organic matter starts under 0 °C. If the temperature rises, the decomposition becomes more intensive, and humidity has less influence on this process. In Germany, in model experiments it has been established that the mineralization of organic nitrogen starts at a temperature of 1 °C above zero; if it rises up to 10 °C above zero, the nitrogen mineralization intensity rises immensely and at 10–30 °C above zero increases 2.5–3 times. It has been also proven that organic nitrogen mineralization occurs within a rather wide range of soil humidity – from 20 to 90% of the total moisture retention capacity of soil (Hanschmann, 1983). In investigations performed in Denmark, the temperature of 3 and 9 °C had no influence on nitrogen mineralization, and the decomposition of organic carbon significantly differed (Magid et al., 2004). In plant residues which decomposed at a temperature of 3 °C above zero, the C : N ratio was higher than in those decomposed at 9 °C above zero. According to investigations in arctic soils, the temperature from 3 to 9 °C above zero did not influence the rate of carbon and nitrogen mineralization; however, the C : N and C : P ratios increased or decreased depending on the temperature. The structure and ecosystem influenced these changes as well (Nadelhoffer et al., 1991). The intensity of organic matter decomposition depends also on the chemical composition of the soil. The decomposition of organic residues in rich secondary mineral soils is slower (Tripolskaja, 2005). Kaboneka et al. (2004) indicate that in acid soils poor in nutrients, to activate straw decomposition processes additional fertilization is necessary.

It is indicated that the improvement of soil by rape growing and the positive impact on the subsequent crops lasts two years. After the growing of rape, more humus was found in the soil than after wheat and less than after clover (Velička, 2002). It is possible that the C : N ratio in rape residues favours decomposition; however, the content of lignin higher than in most of other agricultural plants determines their slower mineralization. However, soil improvement by rape growing has not been scientifically motivated.

The aim of this research was to establish the dependence of rape residue decomposition intensity in *Hypogleyic Cambisol* on their chemical composition and environmental conditions and to compare it with decomposition of wheat and clover residues.

METHODS AND CONDITIONS

Model field experiments were carried out at the Experimental Station of the Lithuanian University of Agriculture (54°53'N, 23°50'E) during the period 2003–2005. The soil of the experimental site according to the soil classification (LTDK-99) is drained moraine loamy *Endocalcari-Epihypogleyic Cambisol* (*sicco*). Humus content (0–25 cm layer) determined by the Tyurin method was 21.0 g kg^{-1}, base saturation > 90%. Its pH_{KCl}, determined by the potentiometric method, was 6.7, total N (by the Kjeldahl method) 1.47 g kg^{-1}, mobile phosphorus (P_2O_5) 119 mg kg^{-1}, mobile potassium (K_2O) 100 mg kg^{-1} (determined by the Egner–Riem–Domingo (A–L) method), sulphur (SO_4^{-2}), determined turbidimetrically, 15.4 mg kg^{-1}. The granulometric composition of the soil was determined with the pipette method according to FAO / ISRIC. In the top soil layer (0–25 cm) there prevailed silt (0.05–0.002 mm) – 55.3% and sand (2–0.05 mm) – 33.8%, while clay particles (<0.002 mm) amounted only to 10.9%.

The experiment had two factors in its design: factor A – crop residues: (1) roots of winter oilseed rape, (2) roots of spring oilseed rape, (3) roots of winter wheat, (4) roots of red clover, (5) stubble of winter oilseed rape (30 cm from root collar), (6) stubble of spring oilseed rape (30 cm from root collar), (7) stubble of winter wheat (20 cm high), (8) stubble of red clover (20 cm high), (9) threshing remains of winter oilseed rape (stems with branches and siliques), (10) threshing remains of spring oilseed rape (stems with branches and siliques), and factor B – decomposition periods: (1) 0 months, (2) 3 months, (3) 7.5 months, (4) 14.5 months, (5) 19.5 months, (6) 26.5 months) (Table 1). The experiment was performed in four replications.

Separated samples of roots, stubble and threshing remains were prepared after the harvesting of winter oilseed rape (*Brassica napus* L. ssp. *oleifera biennis* Metzg.) and spring oilseed rape (*Brassica napus* L. ssp. *oleifera annua* Metzg.). Root and stubble samples of winter wheat (*Triticum aestivum* L.) after harvesting were taken. Sampling of roots and stubble of the second-year red clover (*Trifolium pratense* L.) was done after the first grass cut. Crop residues were chopped in 2–3 cm size

Table 1. **Duration of investigation periods and their meteorological conditions**

LUA Experimental Station, 2003–2005

No of period	Duration of a study period (months from initiation)	Date	Duration of a study period (months)	During a period				
				Average temperature (°C)		Precipitation (mm)	Sum of temperatures (≥ 5°C)	
				Air	Soil at depth of 20 cm		Air	Soil at depth of 20 cm
I	3.0	25 08 2003–01 12 2003	3.0	7.5	9.1	189.9	682.0	817.0
II	7.5	01 12 2003–13 04 2004	4.5	–0.7	1.3	211.3	92.7	56.0
III	14.5	13 04 2004–11 11 2004	7.0	12.7	14.0	417.0	2664.0	2958.0
IV	19.5	11 11 2004–11 04 2005	5.0	–1.1	1.4	216.0	123.0	68.0
V	26.5	11 04 2005–02 11 2005	7.0	13.4	15.0	399.0	2766.0	3102.0

chaffs and the content of their dry matter in them was established. Samples of natural humidity and 20 g weight were taken and put into 9 × 12 cm net polychlorvinyl bags, mesh diameter 0.05 mm. Bags with crop residues were incorporated into ploughed up furrow of black fallow at a depth of 20 cm, spaced 20 cm apart. Samples of all crop residues were incorporated into five furrows for experimental periods (factor B). The initiation and end datum-point of each period was set up when the average temperature at a soil depth of 20 cm for three successive days in spring was ≥5 °C and in autumn ≤5 °C (Table 1). Data on the meteorological conditions were obtained from the Kaunas Meteorological Station. Bags with crop residues at the end of each study period were dug out, cleaned from soil, and the content of dry matter in residues was established. The remaining part of the content in a bag was dried out until air dry weight, and then it was grounded and sieved through a 1-mm separator. The concentration of nutrients was determined in the dry matter of crop residues. The following analyses of samples were performed: dry matter content was determined by drying in a thermostat at a temperature of 105 °C, the content of organic carbon by the Tyurin method, the content of nitrogen by the Kjeldahl method, the lignin content by the Klason method. Statistical analysis of data was performed using the Fisher protected LSD test ANOVA for two-factor experiment and correlation-regression analysis.

Meteorological conditions. The average air and soil (at a depth of 20 cm) temperature, the sum of those temperatures (≥5 °C) and precipitation during the study periods are presented in Table 1. The meteorological conditions of cold and warm periods in different years of investigation were similar. The average air temperature of both cold periods was negative (–0.7 and –1.1 °C), in soil at a depth of 20 cm it was positive (1.3 and 1.4 °C), the precipitation was ~200 mm. The warm period of 2005 was slightly warmer than the same period of 2004, and precipitation was ~400 mm. The fist warm period was shorter than the other two, therefore the sum of temperatures (≥5 °C) was ~4 times lower and there were ~2 times less precipitation. The warm periods were characterised by a sharp shift of prolonged drought, high air temperatures and rainfall.

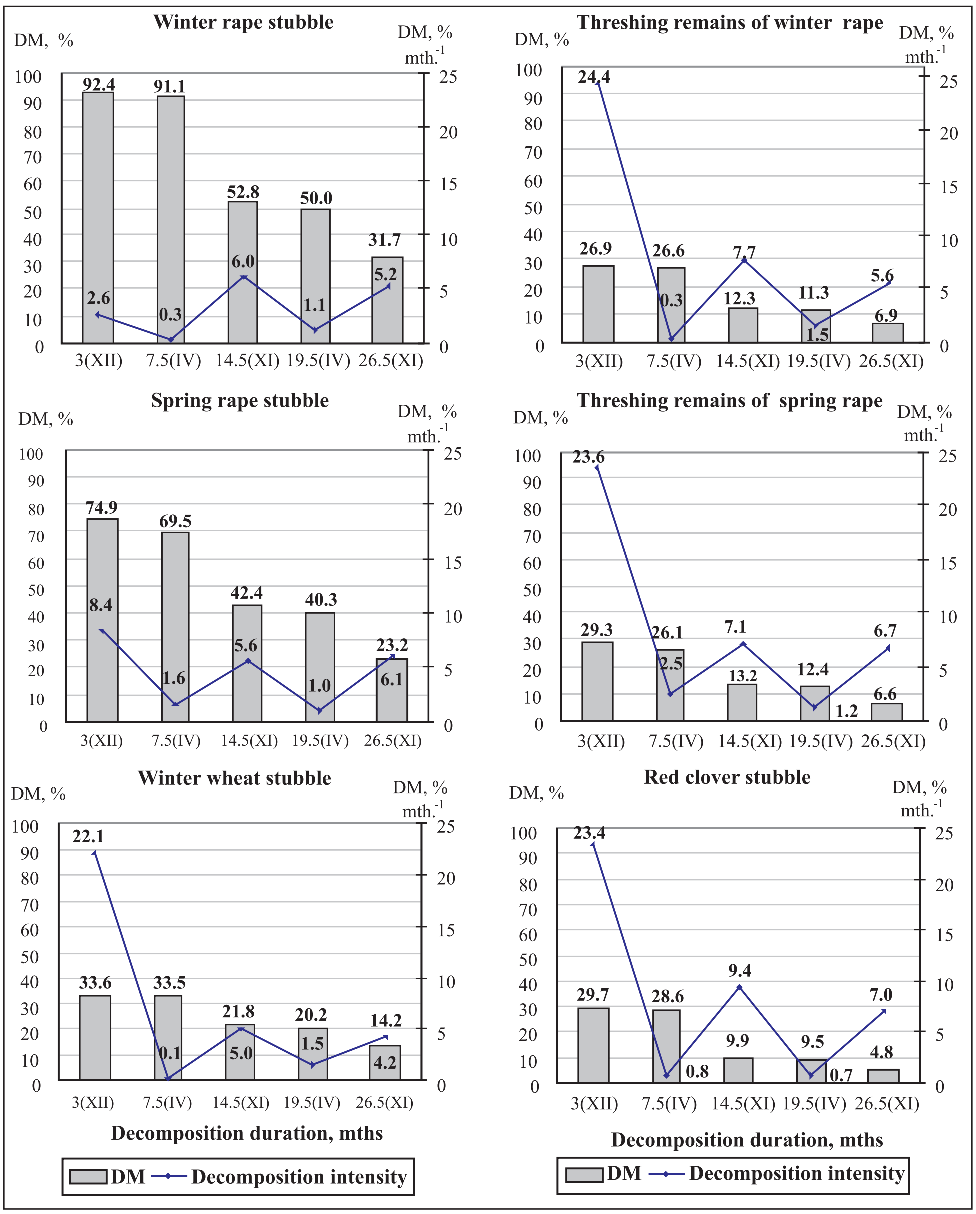

Fig. 1. Dry matter content of terraneous crop residues (%; LSD_{05} = 3.01) and decomposition intensity of crop residues (DM % mth^{-1}; LSD_{05} = 1.22). In brackets, the number of a calendar month is shown

RESULTS AND DISCUSSION

After the first three months, the content of dry matter in all residues significantly decreased (Figs. 1, 2). During this period (August–November), 7.6–73.1% of terraneous residues and 6.4–24.7% of roots decomposed. Rape threshing remains were decomposing especially intensively (70.7–73.1%), and rape stubble, on the contrary, was decomposing slowly (7.6–25.1%). Rape roots were decomposing significantly slower (6.4% of winter rape and 10.6% of spring rape) than those of wheat and clover (both ~25%). Such differences of organic matter decomposition intensity were determined by different chemical composition, C : N, ratio, the content of lignin, glucosinolates present in rape residues (Кононова, 1963; Александрова, 1980; Тейт, 1999).

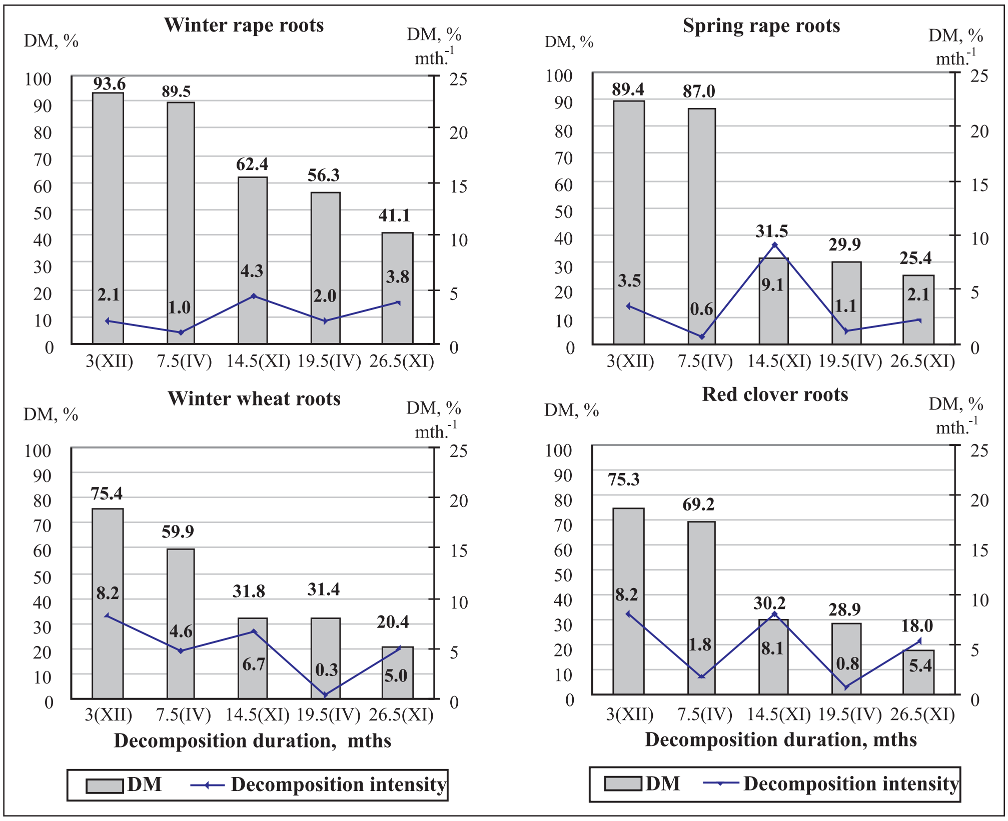

Fig. 2. Dry matter content of crop root residues (%; LSD_{05} = 5.86) and decomposition intensity of crop root residues (DM % mth^{-1}; LSD_{05} = 1.57). In brackets, the number of a calendar month is shown

In the winter of 2003 / 2004 (3.0–7.5 months), a slow organic matter decomposition process was going on. During this period, spring rape residues were decomposing more intensively than the residues of other agricultural plant terraneous parts. The roots of winter wheat and red clover were decomposing more intensively than rape roots. Dry matter content in these residues during the second study period (November–April) significantly decreased. During the second cold period, roots were decomposed significantly more than terraneous parts.

After 14.5 months winter rape roots and stubble were decomposed (respectively 37.6% and 47.2%) significantly less than other residues (terraneous parts 57.6–90.1%, roots 68.2–69.8%). Red clover stubble and rape threshing remains were decomposed mostly in this period of 14.5 months – by 90.1%, winter rape by 87.7% and spring rape by 86.8%.

During the second cold season (November–April 14.5 to 19.5 months) the intensity of decomposition slowed down markedly. During this period, 0.4–2.8% of terraneous plant part residues and 0.4–6.1% of root residues were decomposed. Winter rape roots were decomposing significantly more intensively than other residues, and in them the reduction of dry matter (6.1%) was significant.

During the last period of study (19.5–26.5 months), i. e. during the warm period of the second year, the decomposition of crop residues became more intensive again. In all the residues except spring rape roots, the content of dry matter significantly decreased. During this period, the residues that in the beginning were decomposing slowly decomposed more intensively, obviously due to the fact that in these residues during the decomposition of lignin, the non-lignified carbon had become accessible to microorganisms (Paul et al., 2004). During this period, rape stubble decomposed more intensively than other terraneous part residues: if those of winter rape during a 19.5-mth period were already decomposed by 50.0% and of spring rape by 59.7%, during the last period was decomposed respectively by 18.3% (total 68.3%) and 17.1% (total 76.8%). The other terraneous part residues during the latter period were decomposed by 4.4–6.0% (total 79.8–90.5%). After the period of 19.5 months, the winter rape roots were decomposed less (43.7%) than those of other plants. During this period (19.5–26.5 months), 15.2% of winter rape roots were decomposed (total 58.9%), i. e. more than roots of other plants (Fig. 2).

One of the factors influencing the decomposition of plant residues is their chemical composition. Plant materials are basically composed of similar components, but differ in their proportions which influence the decomposition of residues (Hadas et al., 2004). During the warm period of the first year (7.5–14.5 months), the residues were intensively decomposing. During the decomposition of crop residues and reduction of dry matter content in them, the ratio of organic carbon and nitrogen decreased, and the concentration of lignin was increasing up to 14.5 months (Figs. 3, 4).

In all decomposing crop residues, a positive correlation was established between dry matter and organic carbon content and C : N. The correlation between dry matter and lignin content was negative. In rape stubble and all plant roots, the correlation between dry matter and C; also DM and C : N was statistically significant very strong (r = 0.90**–0.98**) (Table 2). In rape threshing remains and wheat and clover stubble this correlation was weaker (r = 0.65**–0.84**). In terraneous rape residues, the content of dry matter strongly negatively correlated with the content of lignin (r = from –0.78** to –0.87**), and in wheat and clover stubble the correlation between these indicators was medium strong (r = –0.52** and r = –0.64**).

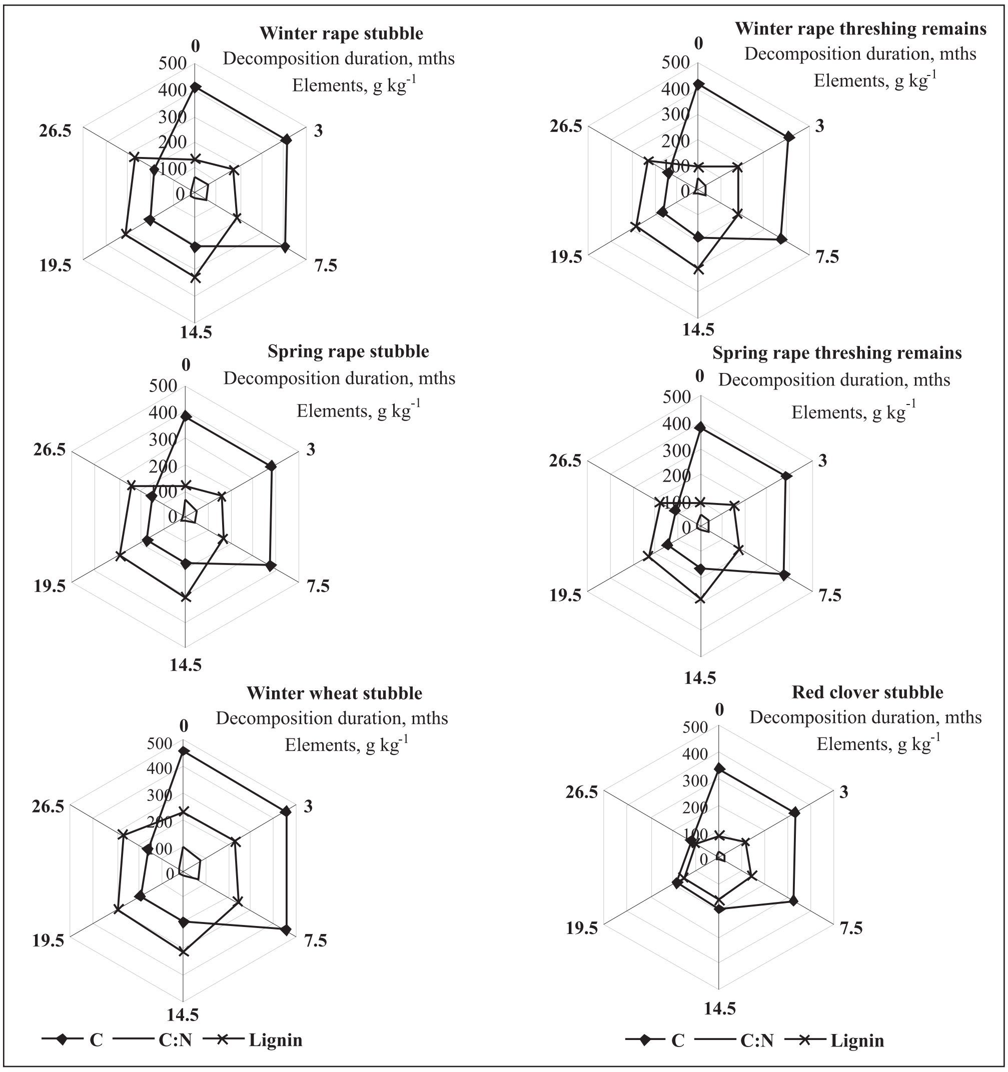

Fig. 3. Changes of organic carbon (LSD_{05} = 7.34) and lignin (LSD_{05} = 22.21) content and C : N ratio (LSD_{05} = 4.01) in crop terraneous residues decomposing in the soil. LUA, 2003–2005

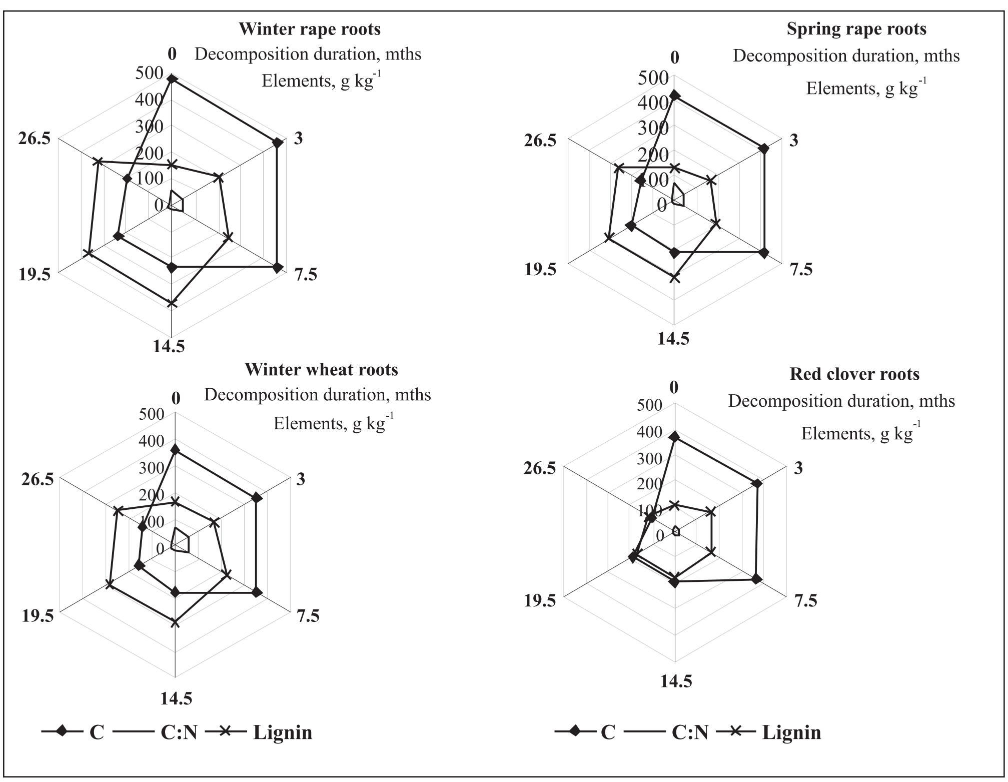

Fig. 4. Changes of organic carbon (LSD_{05} = 6.66) and lignin (LSD_{05} = 20.77) content and C : N ratio (LSD_{05} = 3.93) in crop root residues decomposing in the soil. LUA, 2003–2005

In decomposing rape and wheat roots the correlation was very strong and strong (*r* = from –0.85** to –0.93**), and in clover roots the correlation between these indicators was not established.

The correlation between plant residue decomposition per period and C : N was of medium strength and positive; however, it was established only in rape threshing remains and wheat stubble (*r* = 0.46*–0.56**). The correlation of decomposition intensity per period with lignin was established only in winter and spring rape threshing remains (respectively *r* = –0.54* and –0.61**) and winter rape stubble (*r* = –0.59**). A medium to strong negative correlation (*r* = –0.69** to –0.75**) was established between decomposition intensity per month and lignin content in rape threshing remains and clover stubble. In roots, this correlation was weak and medium (respectively *r* = –0.49* and *r* = –0.56**); however, it was established only in red clover and winter wheat roots.

Table 2. **Influence of the chemical composition of crop residues on decomposition intensity of their in the soil**

LUA Experimental station, 2003–2005

Crop residues	Index (*x*)	DM, g kg^{-1} (y_1)	DM decomposition, % per period^{-1} (y_2)	DM decomposition, % per mth.$^{-1}$ (y_3)
		Coefficient of correlation (r)		
Terraneous parts				
Winter rape stubble	C	0.97**	***–0.67***	***–0.57***
	C : N	0.97**	***–0.69***	–
	Lignin	–0.87**l	***–0.59***	–
Threshing remains of winter rape	C	0.68**	–	***0.49****
	C : N	0.84**	0.56**	–
	Lignin	–0.81**	–0.54*	–0.69*
Spring rape stubble	C	0.92**	–	–
	C : N	0.95**	–	–
	Lignin	–0.82**	–	–
Threshing remains of spring rape	C	0.66**	–	0.50*
	C : N	0.74**	0.47**	–
	Lignin	–0.78**	–0.61**	–0.75**
Winter wheat stubble	C	0.65**	–	***0.46****
	C : N	0.74**	0.46*	–
	Lignin	–0.52**	–	–
Red clover stubble	C	0.69**	–	–
	C : N	0.83**	–	–
	Lignin	–0.64**	–	–0.74**
Roots				
Winter rape	C	0.96**	–0.74**	***–0.64***
	C : N	0.95**	***–0.75***	–
	Lignin	–0.86**	***0.64***	–
Spring rape	C	0.98**	–	–
	C : N	0.95**	***–0.46****	–
	Lignin	–0.93**	***0.52****	–
Winter wheat	C	0.90**	–	***0.45****
	C : N	0.93**	–	–
	Lignin	–0.85**	–	–0.56**
Red clover	C	0.94**	–	–
	C : N	0.97**	–	–
	Lignin	–	–	–0.49*

Notes. * P ≤ 0.01; ** P ≤ 0.05, r in bold italic – content of elements estimated at the end of the period, others – at the beginning of the period.

Dry matter decomposition per month in winter rape stubble correlated only with carbon content established after each period of decomposition (*r* = –0.57**). In spring rape stubble, the correlation between these indicators was not established. Correlation analysis indicated that in rape threshing remains the decomposition intensity was influenced by lignin content. The decomposition was more intensive when the remains contained less lignin. In winter wheat stubble, the correlation between the decomposition per month and C : N (*r* = 0.46*) was medium strong. In red clover stubble, the correlation between decomposition intensity per month and lignin content was strong (*r* = –0.74**) and in the roots medium (*r* = –0.49*).

The decomposition in winter rape roots during the period was more intensive when in the beginning of the period there was less carbon in them (*r* = –0.74**). After intensive decomposition, at the end of the period in roots of both winter and spring rape the C : N ratio was lower (respectively *r* = –0.75** and *r* = –0.46*), and lignin concentration was higher (*r* = 0.64* and *r* = 0.52*). The decomposition of winter wheat per month was more intensive when lignin concentration was relatively lower (*r* = –0.56**) and carbon concentration higher (*r* = 0.45*).

The correlation between decomposition intensity of plant terraneous parts and root residues and meteorological conditions was positive. With an increase of one of agrometeorological indicators (weather and soil temperature, the sum of these temperatures and precipitation) the plant residues decomposed more intensively. The coefficient of correlation between plant terraneous part residue decomposition intensity and meteorological conditions fluctuated from *r* = 0.45* to *r* = 0.98** and that of roots *r* = from 0.60** to *r* = 0.94** (Tables 3, 4).

The temperature and precipitation influenced plant residue decomposition per period more than decomposition intensity per month. These differences are more pronounced in the decomposition of plant terraneous parts than in roots.

Decomposition of rape terraneous part residues per period was more influenced by meteorological conditions than that of wheat stubble. The dependence of rape terraneous part decomposition on the average air and soil temperatures varied from strong to very strong (*r* = 0.71** to 0.95**), and for wheat stubble it was medium (respectively, *r* = 0.61** and *r* = 0.60**). Correlation–regression analysis indicated that 83–96% of rape stubble decomposition per period depended on the air and soil temperature sums (*r* = 0.91**–0.98**), this value for rape threshing being 23–30% (*r* = 0.48*–0.55*), but no direct influence of these parameters on wheat stubble decomposition was established. The decomposition of red clover stubble per period depended less on temperature and precipitation (*r* = 0.45*–0.85**) than that of rape stubble (*r* = 0.80**–0.98**). However, in clover stubble these processes were influenced more strongly than in rape threshing remains in which the correlation of decomposition intensity with air and soil temperatures was *r* = 0.48*–0.78** and there was no correlation with precipitation. In red clover stubble with temperatures it was *r* = 0.65**–0.85** and with precipitation *r* = 0.45*.

A very strong positive correlation was established only between winter rape stubble decomposition intensity (dry matter (DM) % mth^{-1}) and average air and soil temperatures (*r* = 0.92** and *r* = 0.93**), also the sum of these temperatures (≥5 °C) during the period (both *r* = 0.94**).

Table 3. **Influence of meteorological conditions on decomposition intensity of crop terraneous residues in the soil**

LUA Experimental station, 2003–2005

Crop residues	Index (x)	DM decomposition, % per period^{-1} (y_1)		DM decomposition, % per mth.$^{-1}$ (y_2)	
		Regression equation	Coefficient of correlation (r)	Regression equation	Coefficient of correlation (r)
Winter rape stubble	Average air t[x]	$y = 2.85 + 2.46x$	0.89**	$y = 0.81 + 0.34x$	0.92**
	Average soil t	$y = -2.91 + 2.63x$	0.90**	$y = 0.01 + 0.37x$	0.93**
	Precipitation Σ	$y = -30.81 + 0.17x$	0.97**	$y = -3.07 + 0.02x$	0.88**
	Air t (≥5 °C) Σ	$y = 0.69 + 0.01x$	0.98**	$y = 0.68 + 0.002x$	0.94**
	Soil t (≥5 °C) Σ	$y = 1.15 + 0.01x$	0.97**	$y = 0.73 + 0.002x$	0.94**
Threshing remains of winter rape	Average air t	$y = 14.34 + 3.23x$	0.72**	–	–
	Average soil t	$y = 7.26 + 3.38x$	0.71**	–	–
	Precipitation Σ	–	–	–	–
	Air t (≥5 °C) Σ	$y = 20.68 + 0.01x$	0.48*	–	–
	Soil t (≥5 °C) Σ	$y = 20.35 + 0.01x$	0.50*	–	–
Spring rape stubble	Average air t	$y = 7.70 + 2.50x$	0.95**	$y = 2.22 + 0.36x$	0.72**
	Average soil t	$y = 1.95 + 2.65x$	0.95**	$y = 1.43 + 0.37x$	0.72**
	Precipitation Σ	$y = -15.16 + 0.14x$	0.80**	–	–
	Air t (≥5 °C) Σ	$y = 7.81 + 0.01x$	0.91**	$y = 2.88 + 0.001x$	0.50*
	Soil t (≥5 °C) Σ	$y = 8.01 + 0.01x$	0.92**	$y = 2.84 + 0.001x$	0.52*
Threshing remains of spring rape	Average air t	$y = 17.43 + 3.05x$	0.78**	–	–
	Average soil t	$y = 10.74 + 3.20x$	0.77**	–	–
	Precipitation Σ	–	–	–	–
	Air t (≥5 °C) Σ	$y = 23.14 + 0.01x$	0.53*	–	–
	Soil t (≥5 °C) Σ	$y = 22.82 + 0.01x$	0.55*	–	–
Winter wheat stubble	Average air t	$y = 13.20 + 2.28x$	0.61**	–	–
	Average soil t	$y = 8.22 + 2.39x$	0.60**	–	–
	Precipitation Σ	–	–	–	–
	Air t (≥5 °C) Σ	–	–	–	–
	Soil t (≥5 °C) Σ	–	–	–	–
Red clover stubble	Average air t	$y = 12.98 + 4.00x$	0.85**	$y = 4.25 + 0.63x$	0.48*
	Average soil t	$y = 4.15 + 4.20x$	0.84**	$y = 2.94 + 0.65x$	0.46*
	Precipitation Σ	$y = -0.44 + 0.14x$	0.45*	–	–
	Air t (5 °C) Σ	$y = 18.20 + 0.02x$	0.65**	–	–
	Soil t (≥5 °C) Σ	$y = 18.06 + 0.02x$	0.67**	–	–

[x] Temperature.

Table 4. **Influence of meteorological conditions on decomposition intensity of crop root residues in soil**

LUA Experimental station, 2003–2005

Crop residues	Index (x)	DM decomposition, % per period^{-1} (y_1)		DM decomposition, % per mth.$^{-1}$ (y_2)	
		Regression equation	Coefficient of correlation (r)	Regression equation	Coefficient of correlation (r)
Winter rape	Average air t[x]	$y = 6.32 + 1.44x$	0.80**	$y = 1.48 + 0.18x$	0.80**
	Average soil t	$y = 2.88 + 1.55x$	0.81**	$y = 1.05 + 0.19x$	0.80**
	Precipitation Σ	$y = -15.79 + 0.11x$	0.94**	$y = -0.80 + 0.01x$	0.82**
	Air t (≥5 °C) Σ	$y = 4.55 + 0.01x$	0.92**	$y = 1.36 + 0.001x$	0.85**
	Soil t (≥5 °C) Σ	$y = 4.87 + 0.01x$	0.91**	$y = 1.39 + 0.001x$	0.85**
Spring rape	Average air t	$y = 4.31 + 2.35x$	0.64**	$y = 1.14 + 0.33x$	0.62**
	Average soil t	$y = -0.82 + 2.46x$	0.63**	$y = 0.43 + 0.34x$	0.61**
	Precipitation Σ	$y = -28.989 + 0.17x$	0.71**	$y = -2.36 + 0.02x$	0.57**
	Air t (≥5 °C) Σ	$y = 2.39 + 0.01x$	0.70**	$y = 1.12 + 0.002x$	0.60**
	Soil t (≥5 °C) Σ	$y = 2.89 + 0.01x$	0.69**	$y = 1.16 + 0.001x$	0.60**
Winter wheat	Average air t	$y = 12.07 + 2.13x$	0.85**	$y = 3.22 + 0.27x$	0.59**
	Average soil t	$y = 7.46 + 2.22x$	0.84**	$y = 2.69 + 0.28x$	0.57**
	Precipitation Σ	$y = -9.62 + 0.12x$	0.77**	–	–
	Air t (≥5 °C) Σ	$y = 11.88 + 0.01x$	0.84**	–	–
	Soil t (≥5 °C) Σ	$y = 12.09 + 0.01x$	0.84**	–	–
Red clover	Average air t	$y = 7.99 + 2.86x$	0.92**	$y = 2.28 + 0.40x$	0.80**
	Average soil t	$y = 1.59 + 3.02x$	0.91**	$y = 1.41 + 0.42x$	0.79**
	Precipitation Σ	$y = -22.13 + 0.17x$	0.84**	–	–
	Air t (≥5 °C) Σ	$y = 7.50 + 0.02x$	0.91**	$y = 2.841 + 0.002x$	0.60**
	Soil t (≥5 °C) Σ	$y = 7.84 + 0.01x$	0.91**	$y = 2.82 + 0.001x$	0.62**

[x] Temperature.

The correlation between winter rape stubble decomposition intensity per month and precipitation was strong (r = 0.88**). The intensity of spring rape stubble decomposition per month strongly correlated with average air and soil temperatures (both r = 0.72**) and depended also on the sum of these temperatures per period (r = 0.50* and 0.52*). No correlation was established between rape threshing remain decomposition intensity (DM % mth^{-1}) and agrometeorological indicators, and only a medium strength relation was found between red clover stubble decomposition and average air and soil temperatures (r = 0.48* and r = 0.46*), as these residues especially intensively decomposed during the first period (0–3 months) immediately after their incorporation into the soil.

The intensity of crop root decomposition correlated nearly with all meteorological indicators. The correlation between winter and spring rape root decomposition and average air and soil temperatures, also precipitation, the sum of air and soil temperatures (≥5 °C above zero) per period was positive and varied from medium to strong (r = 0.57**–0.94**). The decomposition of winter and spring rape roots within a period was mostly influenced by precipitation (r = 0.94** and r = 0.71**) and that of wheat and clover roots by air and soil temperatures (from r = 0.84** to r = 0.92**).

The intensity of root decomposition per month was most strongly influenced by meteorological conditions in winter rape roots (r = 0.80**–0.85**). For the decomposition of other plant roots this influence was weaker: for spring rape r = 0.57**–0.62**, wheat r = 0.57**–0.59**, clover r = 0.60**–0.80**.

CONCLUSIONS

1. During 26.5 months of investigation, spring rape stubble, winter wheat and red clover, spring and winter rape threshing remains and red clover roots most intensively (8.2–24.4% mth^{-1}) were decomposed during the first three months. The stubble and roots of winter rape were most intensively decomposing during the warm season of the first and second years – stubble by 6.0 and 5.2% mth^{-1} and roots 4.3 and 3.8% mth^{-1}. Spring rape roots were most intensively decomposing during 7.5–14.5 months (by 9.1% mth^{-1}), those of wheat during 0–3 months and 7.5–14.5 months, respectively 8.2 and 8.1% mth^{-1}.

2. Winter rape stubble and roots were decomposing most slowly. At the end of the investigation (after 26.5 months) these residues were decomposed significantly less than the others (respectively 68.3% and 58.9%). After 26.5 months, clover stubble and rape threshing remains were decomposed (95.3% and 93.0%) more significantly than other terraneous plant part residues.

3. The decomposition intensity of plant residues during the warm periods was higher than during the cold periods. During the warm season 7.6–73.1% and during the cold season 0.3–11.2% of terraneous residues were decomposed, and roots 6.4–63.8% and 1.4–20.6%, respectively. During the cold period, roots were decomposed more intensively than the terraneous parts of the plants.

4. In all crop residues, up to 14.5 months lignin concentration was relatively increasing, after 19.5 months the tendency of lignin concentration reduction was established, and after 26.5 months it significantly decreased.

5. During the decomposition of plant residues and reduction of amount of dry matter, C : N in them decreased. In rape stubble and in rape, wheat and clover roots, the correlation between dry matter and C : N was statistically significant very strong positive (r = 0.93**–0.97**), and in other residues this correlation was weaker (r = 0.74**–0.84**).

6. Dry matter content and lignin concentration in all decomposed crop residues showed a negative correlation. In rape terraneous parts, this dependence was strong (r = from –0.78** to –0.87**), and in wheat and clover stubble the correlation between these indicators was medium (r = –0.52** and r = –0.64**). In decomposed spring rape roots, dry matter correlation with lignin was very strong negative (r = –0.93**), in winter rape and wheat roots strong (respectively r = –0.86** and –0.85**), and in clover roots no correlation between these parameters was established.

7. The air and soil temperatures and their sums (≥5 °C) and the precipitation influenced the crop residue decomposition within the study periods more strongly than within a month. In rape stubble, the correlation of these indicators with decomposition intensity within a period (r = 0.89**–0.98**) and with decomposition intensity within a month (r = 0.50*–0.94**) was positive and stronger than in threshing remains (r = 0.48*–0.78**) and wheat and clover stubble (r = 0.45*–0.85**). The intensity of winter rape root decomposition per month depended on meteorological conditions (r = 0.80**–0.85**) more than that of other plants. The decomposition of rape roots within the study periods mostly depended on precipitation (winter rape r = 0.94**, spring rape r = 0.71**), and that of wheat and clover on air and soil temperatures (r = 0.84**–0.92**).

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AUGALŲ LIEKANŲ SKAIDYMOSI DIRVOŽEMYJE PRIKLAUSOMUMAS NUO JŲ CHEMINĖS SUDĖTIES BEI APLINKOS SĄLYGŲ

Santrauka

Augalų liekanų skaidymosi tyrimai atlikti 2003–2005 m. Lietuvos žemės ūkio universiteto Bandymų stotyje, modeliniame lauko bandyme glėjiškajame rudžemyje (*Epihypogleyic Cambisol*). Nustatyti rapsų, kviečių ir dobilų liekanų skaidymosi intensyvumo priklausomumai nuo jų cheminės sudėties bei meteorologinių sąlygų.

Nustatyta, kad rapsų, kviečių ir dobilų liekanoms skaidantis dirvožemyje 26,5 mėn. ir mažėjant sausųjų medžiagų kiekiui, jose mažėjo organinės anglies bei C ir N santykis, o lignino koncentracija sąlyginai didėjo iki 14,5 mėn. Visose augalų liekanose po 19,5 mėn. nustatyta lignino koncentracijos mažėjimo tendencija, o po 26,5 mėn. ji esmingai sumažėjo.

Rapsų kūlenos (žieminių – 24,4, vasarinių – 23,6% mėn.$^{-1}$), kviečių (22,1% mėn.$^{-1}$) ir dobilų (23,4% mėn.$^{-1}$) ražienojai intensyviausiai skaidėsi per pirmuosius 3 mėnesius po jų įterpimo į dirvą. Rapsų ražienojai skaidėsi lėčiau – šiltųjų laikotarpių metu: žieminių – 2,6–6,0% mėn.$^{-1}$, vasarinių – 5,6–8,4% mėn.$^{-1}$. Kviečių ir dobilų šaknys intensyviausiai skaidėsi pirmojo (po 8,2% mėn.$^{-1}$) ir antrojo (atitinkamai 6,7 ir 8,1% mėn.$^{-1}$) šiltojo laikotarpio metu, rapsų vėliau – antrojo (žieminių – 4,3, vasarinių 9,1% mėn.$^{-1}$) ir trečiojo (žieminių – 3,8% mėn.$^{-1}$) šiltojo laikotarpio metu. Po 26,5 mėn. žieminių ir vasarinių rapsų ražienojai buvo suskaidyti (atitinkamai 68 ir 77%) mažiau nei jų kūlenos (abiejų 93%), kviečių (86%) ir dobilų (95%) ražienojai.

Rapsų ražienojuose ir rapsų, kviečių ir dobilų šaknyse koreliacija tarp sausųjų medžiagų ir C : N buvo statistiškai patikima labai stipri teigiama (r = 0,93**–0,97**), o kitų dalių liekanose ši koreliacija silpnesnė (r = 0,74**–0,84**). Rapsų antžeminėse liekanose sausųjų medžiagų kiekis neigiamai koreliavo su lignino kiekiu (r = nuo –0,78** iki –0,87**), o kviečių ir dobilų ražienojuose šių rodiklių koreliacija buvo vidutinė, atitinkamai r = –0,52** ir r = –0,64**. Skaidomose vasarinių rapsų šaknyse sausųjų medžiagų koreliacija su ligninu buvo neigiama labai stipri (r = –0,93**), žieminių rapsų ir kviečių šaknyse – stipri (atitinkamai r = –0,86** ir –0,85**), o dobilų šaknyse koreliacijos tarp šių rodiklių nenustatyta.

Oro ir dirvos temperatūra bei jų suma (≥5 °C) ir kritulių kiekis per laikotarpį augalų liekanų susiskaidymą per laikotarpį veikė labiau nei jų skaidymo intensyvumą per mėnesį. Rapsų ražienojuose šių agrometeorologinių rodiklių koreliacija su skaidymo intensyvumu per laikotarpį (r = 0,89**–0,98**) ir su skaidymo intensyvumu per mėnesį (r = 0,50*–0,94**) buvo stipresnė nei kūlėnose (r = 0,48*–0,78**) ir kviečių bei dobilų ražienojuose (r = 0,45*–0,85**). Žieminių rapsų šaknų skaidymo intensyvumas per mėnesį nuo meteorologinių sąlygų priklausė (r = 0,80**–0,85**) labiau nei kitų augalų (r = 0,57**–0,80**). Rapsų šaknų susiskaidymas per laikotarpį labiausiai priklausė nuo kritulių kiekio (žieminių r = 0,94**, vasarinių r = 0,71**), o kviečių ir dobilų – nuo temperatūros (r = 0,84**–0,92**).

Raktažodžiai: žieminių ir vasarinių rapsų, žieminių kviečių ir raudonųjų dobilų liekanos, C : N, ligninas, temperatūra, krituliai, koreliacija