nodrošina stabilu graudu ražas pieaugumu- vidēji par 0.76 t ha^{-1}.Vislielāko ražas pieaugumu efektu – 1.05 t ha^{-1} dod kompleksa fungicīdu un herbicīdu lietošana miežu atkārtotas audzēšanas variantā. Miežu sējumos nezāļu daudzumus palielinās augsekās ar graudaugu īpatsvaru virs 83%. It sevišķi izteikti vairāk ir daudzgadīgo nezāļu, galveno kārt ložņu vārpatas *Elytrigia repens*, ir miežu atkārtotas audzēšanas variantos. Auzas, augsekas ar graudaugu īpatsvaru līdz 83%, maz reaģēja uz to izvietojumu pēc dažādiem priekšaugiem. Būtisks ražas samazinājums ir variantos, kur tās audzē atkārtoti. Auzu atkārtotas audzēšanas variantos, lietojot herbicīdu un fungicīdu kompleksu smidzinājumu, panākts vislielākais auzu ražu pieaugums (+0,86 t ha^{-1}), bet tas nenodrošināja tik augstu auzu ražu kā labākajos augseku variantos. Auzu sējumos nezālainība, kur tās sētas pēc ziemas rudziem, kā arī atkārtotas audzēšanas variantos, ir ievērojami lielāka kā pēc kartupeļiem. Tā atkārtotas audzēšanas variantos nezāļu skaits ir 10 un vairāk reizes lielāks kā auzās, kuras audzētas augmaiņā. Augstākās vasaras kviešu ražas ir pēc griķiem un lupīnas. Graudaugu bezmaiņas sējumos herbicīdu un fungicīdu efektivitāte ir lielāka kā augsekās. Nezālainība vasaras kviešos pieaug augseku variantos, ar lielāku graudaugu īpatsvaru

EFFECT OF LONG-TERM APPLICATION OF DIFFERENT FERTILIZATION ON THE FERTILITY OF GLEYIC CAMBISOL

Maiksteniene S., Kristaponyte I., Masilionyte L.
Joniskelis Experimental Station of the Lithuanian Institute of Agriculture, LT-39301, Joniskelis, Pasvalys distr. phone: +370 451 38224, e-mail.: joniskelio_lzi@post.omnitel.net

Abstract
Long-term stationary trials were conducted on a clay loam *Gleyic Cambisol* medium in phosphorus supply (0.057 g kg^{-1}) and very high in potassium supply (0.174 g kg^{-1}) in a five-course crop rotation. The trials were designed to study the effects of different fertilisation systems – mineral, organic – mineral and organic on the changes in soil agrochemical properties, nutrient balance and crop productivity. It was found that in the mineral fertilisation system (annual avg. $N_{56}P_{48}K_{60}$) soil humus and phosphorus contents per rotation remained close to the initial level, while potassium content inappreciably declined. In the organic – mineral fertilisation system the incorporation of different farmyard manure rates (40; 60 and 80 t ha^{-1}) and NPK as much as in the mineral fertilisation system resulted in a significant increase in humus (11.5-14.5 %), available phosphorus (22.4-36.3 %) and potassium did not change significantly over two rotation. In all organic – mineral fertilisation systems positive changes in humus and other agrochemical indicators had a considerable effect on soil structure. The content of metabolisable energy of the crop rotation plants was directly dependent on the contents of phosphorus (r=0.97**) and nitrogen (r=0.86*) incorporated with organic and mineral fertilisers.

Key words: clay loam, crop rotation, fertilization systems, humus, phosphorus, potassium, metabolisable energy.

Introduction
When crops are intensively fertilised with only mineral fertilisers, they are unevenly supplied with nutrients at different stages of development, since due to the uneven distribution of rainfall, part of the nutrients are leached during the growing period, and the shortage of nutrients causes stress to plants (Jenkinson, 2001; Edmeades, 2003). However, when fertilising with organic fertilisers, they mineralise and create a nutrient reserve which can secure more consistent plant nutrition throughout the whole growing period, therefore the plants form vegetative and generative organs more intensively (Helander and Delin, 2004; Tripolskaja, 2005). In fine-textured soils due to the high abundance of clay particles and poorer aeration, the mineralization of organic matter occurs more slowly and this determines the specific action of organic fertilisers and a longer period of nutrient release, compared with courser-textured soils. This determines the specific organic fertiliser action to maintain soil potential productivity and to increase crop rotation productivity

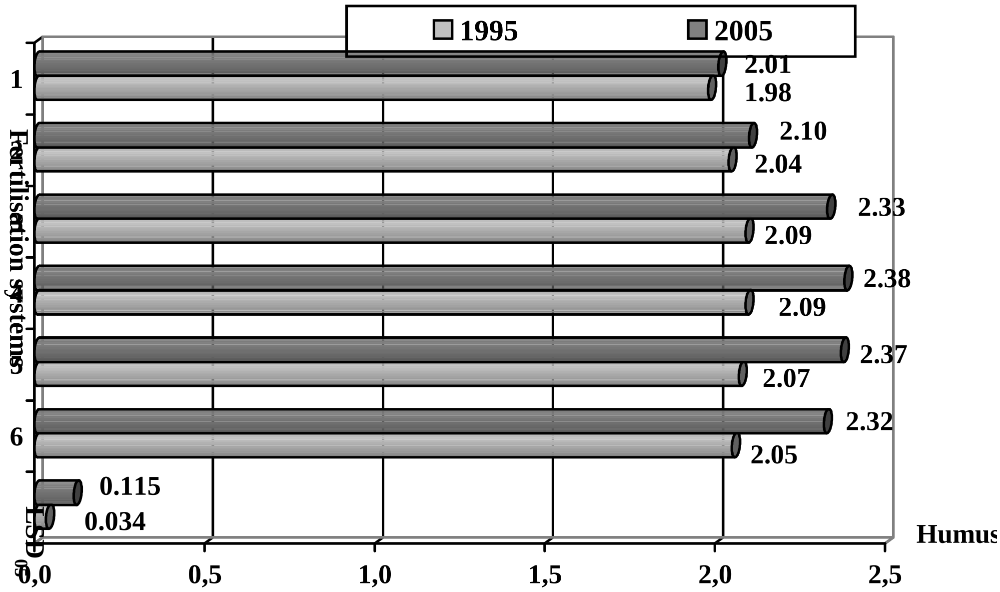
(Maiksteniene, 2002). The data obtained by many authors the yield-increasing effect of stable manure was also felt in the second and third years, especially when lower N rates were applied (Kismanyoky and Kiss, 1998).
Experiments designed to compare mineral and organic–mineral fertilisation systems were carred at the Lithuanian Institute of Agriculture's Joniskelis Experimental Station with 40 t ha^{-1} farmyard manure (FYM) once per six-course rotation, 6-7 t ha^{-1} FYM per year and the application of optimal mineral NPK fertiliser rates did not secure the stability of humus (Kristaponyte, 2001). As a result, since 1995 the experiment has been reconstructed aiming at a positive humus and nutrients balance, in which organic – mineral fertilisation systems with increased organic fertiliser rates 60-80 t ha^{-1} and organic system with 80 t ha^{-1} FYM are investigated. The objective of the experiment was to estimate the effect of fertilisation systems differing in intensity, on the dynamics of nutrients and humus in heavy soils.

Material and Methods

The soil of the experimental site is characterised as an *Endocalcari-Endohypogleyic Cambisol (CMg-n-w-can)*, and according to its texture – clay loam on silty clay. The agrochemical characteristics of the topsoil were as follows: humus (Tyurin`s method) 1.98 %, available phosphorus (A-L method) 0.020 g kg^{-1}, available potassium (A-L method) 0.147 g kg^{-1} of the soil. The following fertilisation systems were investigated: mineral, organic, and organic-mineral. The experiment was replicated four times, the size was 105.0-112.5 m^2, of record plots 45-50 m^2. The trial involved the following five - course crop rotation: sugar beet, spring barley, first year (1st) perennial grasses, second year (2nd) perennial grasses, winter wheat. Organic fertilisers (farmyard manure) at a rate of 40; 60 and 80 t ha^{-1} were applied sugar beet once per rotation. The average composition was as follows: total N (according to Kjeldahl) – 0.34 %, phosphorus (calorimetric method) 0.20 %, potassium (flame photometer) – 0.65 %. Ammonium nitrate, granulated superphosphate and potassium chloride were used as mineral fertilisers. Mineral fertiliser rates were applied in relation to the crops grown: sugar beets received $N_{120}P_{90}K_{120}$, spring barley - $N_{30}P_{60}K_{60}$, first year (1st) perennial grasses – $P_{50}K_{60}$, second year (2nd) perennial grasses – N_{60}, winter wheat – $N_{70}P_{40}K_{60}$.
The productivity of the crop rotation crops was re-calculated into metabolisable energy according to the coefficients of yield chemical composition set for separate crops yield (Jankauskas, 1999).
Meteorology. The weather conditions during the crop growing seasons were evaluated according to hydrothermal coefficient (HTC). Having summarised the weather conditions during the crop growing season it was found that during the experimental period, the plant growing seasons in 1996; 1997; 1999; 2003 and 2004 were normally wet (HTC 1.12-1.26 and 1.27; 1.07 and 1.20), in 1998 and 2001 there was excessive moisture (HTC – 2.08 and 2.14). In 2000 and 2005 the growing season was dry (HTC – 0.90 and 0.97) and only in 2002 the droughty season (HTC-0.60).
Statistical analysis. Experimental findings were processed by the analysis of variance and correlation regression methods (Tarakanovas, 1999). The credibility of equations was determined according to the Fisher criterion (r of ŋ) at a 95 % probability level (marked as*), 99 % (marked as**).

Results and Discussion

Humus. In the crop rotation with two fields of perennial grasses after two crop rotation (ten experimental years) the content of humus in the control treatment (without fertilisers) in the 0-20 cm depth did not decline (figure 1). In the mineral fertilisation system which received on average $N_{56}P_{48}K_{60}$ annually (treatment 2) the content of humus was increase by 0.06 percentage units compared with the initial level. Organic – mineral fertilisaton systems of various intensity had a different effect on the build up of humus in the soil. In the organic – mineral fertilisation system having incorporated 40 t ha^{-1} FYM, the content of humus in the topsoil significantly increased by 0.24 percentage units, having incorporated 60 t ha^{-1} FYM by 0.29 percentage units and having incorporated 80 t ha^{-1} FYM by 0.30 perc units, compared with the initial level.



Fertilisation systems: 1. Without fertilisers; 2. $N_{56}P_{48}K_{60}$; 3. 40 t ha^{-1} of farmyard manure + $N_{56}P_{48}K_{60}$; 4. 60 t ha^{-1} of farmyard manure + $N_{56}P_{48}K_{60}$; 5. 80 t ha^{-1} of farmyard manure + $N_{56}P_{48}K_{60}$; 6. 80 t ha^{-1} of farmyard manure.

Figure 1. The effect of different fertilisation systems on the changes of humus in the soil

In different organic – mineral fertilisation systems, compared with the mineral fertilisation system content of humus, increased by 0.23; 0.28; 0.27 percentage units, however, there were no significant differences between different FYM rates. In the organic fertilisation system having incorporated 80 t ha^{-1} FYM only, the humus content increased by 0.27 percentage units over two rotations, compared with its initial level and 0.22 percentage units with mineral fertilisation system. This suggests that in the organic – mineral fertilisation system more favourable conditions occurred for organic matter humification and humus accumulation in the soil than in solely organic or mineral system. The correlation – regression analysis shows that soil humus content in the plough layer was strongly dependent on the nutrients incorporated with organic and mineral fertilisers: with potassium r=0.90**, with nitrogen r=0.68*, and a slightly weaker relationship with phosphorus r=0.50.

Available phosphorus. After crop two rotation with no fertilisation to all crops the amount on available phosphorus declined by 37.9 % (Table 1).

Table 1. The effect of different fertilisation systems on the agrochemical properties of heavy-textured soils

Fertilization systems	P			K		
	1995	2005	±	1995	2005	±
	g kg^{-1} soil					
Without fertilizers	0.029	0.018	-0.011	0.155	0.143	-0.012
Mineral NPK	0.039	0.040	0.001	0.161	0.161	0
Organic-mineral (I) FYM 40 t ha^{-1}+NPK	0.051	0.062	0.011	0.172	0.168	-0.004
Organic-mineral - (II) FYM 60 t ha^{-1}+NPK	0.055	0.071	0.016	0.181	0.178	-0.003
Organic-mineral- (III) FYM 80 t ha^{-1}+NPK	0.055	0.074	0.019	0.174	0.182	0.008
Organic FYM 80 t ha^{-1}	0.055	0.055	-	0.178	0.181	0.003
LSD_{05}	0.005	0.013		0.013	0.0180	

In the mineral fertilisation system which received on average $N_{56}P_{48}K_{60}$ annually, the content of available phosphorus inappreciably increased by 2.6 %, compared with its initial level. In the organic – mineral fertilisation systems of different intensity having incorporated 40 t ha^{-1} FYM and optimal NPK fertiliser rates, the content of phosphorus, compared with its initial level, increased by 21.6 % and having incorporated 60 and 80 t ha^{-1} FYM and NPK fertilisers, phosphorus content significantly increased by 29.1 % and 34.5 %, respectively. Having incorporated higher FYM rates

60 and 80 t ha^{-1} (treatments 4 and 5) soil phosphorus content significantly increased, compared with the mineral fertilisation system (treatment 2). In the organic fertilisation system having incorporated 80 t ha^{-1} FYM once per rotation (treatment 6) the soil phosphorus content, compared with the mineral fertilisation system, increased by 37.5 %. Such results were determined by the fact that in the case of mineral fertilisation the yields of the crop rotation plants were relatively high and higher contents of phosphorus were removed with the yields.

Available potassium. The content of available potassium in the unfertilised treatment also inappreciably declined, compared with its initial level, since crops utilising much potassium were cultivated in the crop rotation, especially sugar beet which removed 126-226 kg ha^{-1} of potassium with by-production (Table 1). In the organic – mineral fertilisation system having incorporated 40 and 60 FYM and optimal NPK amounts, the content of available potassium in the soil decreased by 2.3 and 1.7 % over two rotations. Having incorporated 60 and 80 t ha^{-1} FYM, the content of available potassium in the plough layer was significantly (by 5.9 and 8.4 %) higher compared with the treatments that had received the lower 40 t ha^{-1} FYM rate. In the organic fertilisation system the content of available potassium did not change significantly per rotation, however, compared with the mineral fertilisation system it significantly increased by 12.4 %.

Metabolisable energy. For the final assessment of the effects of the fertilisation systems on the changes in soil agrochemical properties, the productivity of the crop rotation crops was recalculated into metabolisable energy. While estimating fertilisation systems it was found that in the mineral fertilisation system which received on average $N_{56}P_{48}K_{60}$ annually, the metabolisable energy of the crops increased by 70.2 %, compared with the unfertilised treatment; a more significant increase 101.2 % was identified for by-production than for primary production 62.9 % (Table 2).

Table 2. Metabolisable energy accumulated by the crop rotation crops in different fertilisation systems 1995-2005.

Fertilization systems		For rotation, GJ ha^{-1}			Average in the years, GJ	Increase	
		primary produc-tion	by-produc-tion	common		GJ	%
Without fertilizers		1987.6	465.1	2452.7	490.5	-	-
Mineral NPK		3237.1	935.7	4172.8	834.6	344.6	70.2
Organic – mineral 40 t ha^{-1} FYM+NPK	I	3491.0	1067.9	4558.9	911.8	421.8	85.9
Organic – mineral 60 t ha^{-1} FYM+NPK	II	3625.1	1142.4	4767.5	953.4	463.4	94.4
Organic – mineral 80 t ha^{-1} FYM+NPK	III	3592.8	1114.4	4707.2	941.4	451.4	91.9
Organic 80 t ha^{-1} FYM		3022.8	748.6	3771.4	754.3	264.3	53.8
LSD_{05}		167.45	172.88	118.84	23.77	-	-

In the mineral fertilisation system one kilogram of NPK gave an increase in metabolisable energy of 2.10 GJ ha^{-1}. In the organic – mineral fertilisation systems the metabolisable energy of the crop rotation crops increased by 85.9; 94.4 and 91.9 %, compared with the unfertilised treatment. A significant increase of 9.3 and 14.3 % in metabolisable energy occurred in the organic – mineral fertilisation systems that received 40 or 60 t ha^{-1} FYM, compared with the mineral fertilisation system. In the organic-mineral fertilisation system having increased FYM rate to 80 t ha^{-1}, the amount of metabolisable energy increased by 106.8 GJ or 12.8 %, compared with the mineral fertilisation system. In the organic fertilisation system involving 80 t ha^{-1} FYM, with which $N_{55}P_{32}K_{104}$ was incorporated per year, the metabolisable energy of the rotation crops increased by 53.8 %, compared with the unfertilised treatment. Although in this system the amount of potassium incorporated with organic fertilisers was 73.3 % higher than in the mineral fertilisation system, the amount of phosphorus incorporated was 33.3 % lower. In the organic fertilisation system the amount of metabolisable energy accumulated was significantly lower by 9.6 % than in the mineral fertilisation system. More over, this was determined by lower plant nutrient utilisation coefficients (N-51.4; K-59.8 %), compared with mineral fertilisers, as well as by the shortage of phosphorus in low-phosphorous heavy-textured gleyic cambisols (their genetic characteristic). One kg of NPK present in farmyard manure increased the metabolisable energy content by 1.38 GJ, and this is by 34.3 % less than by 1 kg of mineral fertilisers.

The total metabolisable energy of the crop rotation crops (y) directly depended on the content of nitrogen (x_1) and phosphorus (x_2) incorporated with mineral and organic fertilisers: $y=3195.092+2.912x_1$; r=0.885*; $y=3135.079+4.221x_2$; r=0.974**.

In the soils high in potassium there was no significant relationship between the productivity of the crop rotation crops and the potassium content introduced with fertilisers y=3601.953+1.361x; r=0.64.

Making direct comparisons between mineral and organic farming systems is fraught with difficulty. Many authors suggest that on clay loam soils the organic - mineral fertilisation system is the best choice (Zarina, 2000; Tripolskaja, 2005). Such a system creates conditions for the balance between mineralization and the humification processes, since due to the poor aeration, the destructive process of organic matter is longer, and it is promoted by the incorporation of mineral nitrogen (Kurnisieva *et al.*, 1996; Perucci *et al.*, 1997). This suggests that in the organic – mineral fertilisation system more favourable conditions occurre for organic matter humifications and humus accumulation in the soil than in solely organic or mineral systems.This confirms some of authors` conclusions that in order to maintain positive humus balance, it is necessary to incorporate on average 8-16 t ha^{-1} FYM annually during the five-course crop rotation (Kristaponyte, 2005). According to many authors (Niggli *et al*., 1999), systematic soil fertilisation with moderate farmyard manure rates (30-60 t ha^{-1}) has a positive effect on almost all soil properties. Farmyard manure application improves agrochemical soil properties: soil acidity declines, the contents of major nutrients (nitrogen, phosphorus, potassium) and trace nutrients increase their plant availability improves, and humus content increases (Kiss and Kismanyoky, 1998). However, the results do offer support to the argument that organic manure is mining reserves of P and K built up by conventional management. Changes in the content of available phosphorus and potassium in the soil depend on the fertilisation intensity (Smith *et al*., 2001), however the variation of the potassium content at the same rates as phosphorus is lower (Schneider, 1997; Magid *et al*., 1999). Zarina (2000) reported that the content of phosphorus and potassium changed the minerals in the fertilisation system with stable manure 20 t ha^{-1}, but increased essential in other studied fertilisation systems. The correlation – regression analysis of our experiments shows that the soil phosphorus content (g kg^{-1}) was strongly dependent on the nutrients incorporated with mineral and organic fertilisers and their combinations: with nitrogen r=0.91*, with phosphorus r=0.76*, and with potassium r=0.98**.

Conclusions

On a fine-textured *Gleyic Cambisol* in the mineral fertilisation system (with average annual application of $N_{56}P_{48}K_{60}$) the humus content per five-course rotation with two fields of perennial grasses did not change, compared with the initial level. In the organic – mineral fertilisation systems, having applied to sugar beet 40; 60 and 80 t ha^{-1} of FYM and the same amount of NPK as in the mineral system, the humus content increased by 11.0; 13.3 and 12.9 %, respectively, and in the organic fertilisation system (80 t ha^{-1} FYM) by 10.5 %, compared with the mineral fertilisation system.

In the organic – mineral fertilisation systems the incorporation of different farmyard manure rates (40; 60 and 80 t ha^{-1}) and NPK much as in the mineral fertilisation system, resulted in a significant increase in available phosphorus (21.6; 29.1 and 24.5 %) over two rotations. The higher FYM of 60 and 80 t ha^{-1}, increased the content of available phosphorus in the soil by 14.5 and 19.4 %, compared with the lower FYM rate (40 t ha^{-1}). In the organic – mineral fertilisation systems the content of available potassium significantly increased by 4.3; 12.4 and 13.0 %, compared with the mineral fertilisation system and by 6.0 and 8.3 %, compared with the lower FYM rate (40 t ha^{-1}).

With improving agrochemical properties of heavy-textured soils in the organic – mineral fertilisation systems having applied 40; 60 and 80 t ha^{-1} FYM, the metabolisable energy of the crop rotatim plants was 9.3; 14.3 and 12.8 % higher, compared the mineral fertilisation systems however, there were no significant differences between separate FYM rates. In the organic fertilisation system having incorporated 80 t ha^{-1} FYM, the content of metabolisable energy accumulated by the crops was 53.8 % higher, compared with unfertilised, but 9.6 % lower compared with the mineral fertilisation system.

References

1. Edmeades D.C. (2003). The long-term effects of manures and fertilisers on soil productivity and quality. *Nutrient Cycling in Agroecosystems*, 66, 165-180.
2. Helander C.A., Delin K. (2004). Evaluation of farming systems according to valuation indices developed within a European network on integrated and ecological arable farming system. *European Journal of Agronomy*, 21, 53-67.
3. Jankauskas B., Jankauskienė G., Švedas A. (1999) Derliaus energetinio įvertinimo metodų patikslinimas: *užbaigtų tiriamųjų darbų konferencijų pranešimai* / LŽI. Akademija, 31, 63-65.
4. Jenkinson D. S. (2001). The impact of humans on the nitrogen cycle, with focus on temperate arable agriculture. *Plant and Soil*, 228, 3-15.
5. Kismanyoky T., Kiss L. (1998). Effect of various organic and mineral fertilisers on cereal yields in long-term experiments. *Novenytermeles*, 47, 3, 313-326.
6. Kiss L., Kismanyoky T. (1998). Effect of various organic manures and mineral fertilisers on the humus content of the soil in long-term experiments. *Novenytermeles.* 47, 4, 439-448.
7. Kristaponyte I. (2001). Changes in agrophysical properties of clay loam soils in relation to different fertilization systems. Modern ways of soil tillage and assessment of soil compaction and seedbed quality. 1st International conference of BSB of ISTRO. *Tartu-Estonia*, 141-149.
8. Kristaponyte I. (2005). Effect of fertilisation systems on the balance of plant nutrients and soil agrochemical properties. *Agronomy Research*, Estonia, 3, 45-54.
9. Kurnisieva N.A., Efremov V.F., Trofimova N.P. (1996). Znacenie sistem udobrenija sevooborotov v regulirovaniji gumusnogo rezima dernovo – podzolistoj pocvy v uslovijach intensivnogo zemledelija. *Agrochimija*, 12, 10-16.
10. Magid J., Jensen M., Mueller T. et al. (1999). Phosphate leaching responses from unpreturebed anaerobic or cattle manured mesotrofic sandy loam soils. *Journal of Environmental Quality*, 28, 1796-1803.
11. Maiksteniene S. (2002). Use of green manure for the fertility improvement of heavy soils. Scientific aspects of organic farming. *Proceedings of the conference held in Jelgava*, Latvia. 158-162.
12. Niggli U., Flieβbach A., Mäder P. (1999). Yield of grass clover crop rotation and soil fertility in organic and conventional farming systems. *On the way to Europe with organic products*, 92-102.
13. Perucci J., Bonciarelli U., Santilocchi R. and Bionchi A.A. (1997). Effect of rotation, nitrogen fertilization and management of crop residues on some chemical, microbiological and biochemical properties of soils. *Biology and Fertility of Soils*, 24, 3, 311-316.
14. Schneider A. (1997). Release and fixation of potassium by a loamy soil as affected by initial water content and potassium status of soil samples. *European Journal of Soil Science*. 48, 2, 263-271.
15. Smith K.A., Jackson D.R., Withers P.J.A. (1991). Nutrient losses by surface run-off following the application of organic manures to arableland. 2. Phosphorus. *Environmental Pollution*, 112, 53-60.
16. Tarakanovas P. (1999). The programs package “Selekcija” for processing statistical data. Lithuania.-57
17. Tripolskaja L. (2005). Organines trasos ir ju poreikis aplinkai. *Monografija*, Lietuva.-212.
18. Zarina L. (2000). Results of long-term crop rotations experiments in Priekuli. The results of long-term field experiments in Baltic States. *Proceedings of the International Conference*. Jelgava, Latvia. 179-185.

DAŽĀDA MĒSLOJUMA ILGLAICĪGAS PIEMĒROŠANAS IETEKME UZ *GLEYIC CAMBISOL* AUGLĪGUMU

Maiksteniene S., Kristaponyte I., Masilionyte L.

Ilglaicīgi stacionāra izmēģinājumi tika veikti māla augsnē *Gleyic Cambisol*, vidēji bagātā ar fosfora krājumiem (0.057 g kg^{-1}) un ļoti augstiem kālija krājumiem (0.174 g kg^{-1}), piecu-lauku augu sekā. Izmēģinājumi tika plānoti, lai izpētītu dažādu mēslošanas sistēmu – minerālās, organo-minerālās un organiskās – ietekmes uz augsnes agroķīmisko īpašību, barības vielu līdzsvara un laukaugu ražīguma izmaiņām. Tika atklāts, ka minerālajā mēslošanas sistēmā (vidēji gadā $N_{56}P_{48}K_{60}$) augsnes humusa un fosfora saturs augsekā saglabājās tuvs sākotnējam līmenim, bet kālija saturs nedaudz samazinājās. Organo-minerālajā mēslošanas sistēmā dažādu kūtsmēslu normu (40; 60 un 80 t ha^{-1}) un NPK tikpat, cik minerālājā mēslošanas sistēmā, tika iegūts nozīmīgs humusa un pieejamā fosfora pieaugums, attiecīgi 11.5-14.5 % un 22.4-36.3 %, bet kālijs divās pilnās augsekas rotācijās mainījās maz.

Visās organo-minerālajās mēslošanas sistēmās pozitīvajām humusa un citu agroķīmisko rādītāju izmaiņām bija vērā ņemama ietekme uz augsnes struktūru. Augu sekas augu saistītās enerģijas

daudzums bija tieši atkarīgs no fosfora (r=0.97**) un slāpekļa (r=0.86*) satura, kas iekļauts ar organisko un minerālmēslojumu.

THE SOIL ACIDITY PARAMETERS OF SOILS WITH STOPPED LIMING

Marcinkonis S, Tripolskaja L.
Lithuanian institute of Agriculture Voke branch, Zalioji a. 2, Vilnius, Lithuania, LT-02232
phone: +370 52645439, e-mail: saulius.marcinkonis@voke.lzi.lt

Abstract
The present problem is mass soil acidification in the whole of Lithuania, especially in the eastern and western regions and soil variability in the acidification stages. The results of the last stage (2002-2006) of the long-term experimental work carried out at the LIA Voke branch since 1972, demonstrate that the effect of primary soil liming is statistically significant only for mobile Al. Changes in the periodically limed soil pH, hydrolytic acidity and mobile Al were more intense and their restoration to previous levels is slower compare to primary limed. In such soils even after 14-23 years since last the lime application the productivity of crop rotation is still higher than in unlimed soils.
Our conclusions clarified questions about the use of agricultural soils with stopped liming – what soil parameters can identify soil acidity and what is the lime requirement of previously limed soils? It suggest further investigations into the effects of stopping liming on soil profile chemical properties changes, especially the dynamic of mobile Al restoring. The selection of new criteria for lime requirements and the optimal lime rate determination concerning ecological and economical efficiency are the most important questions for maintaining the productivity of these acidifying soils. Only the further monitoring of the soils will enable a more detailed evaluation of the liming effect on the environment and make accurate predictions about the restoration of soil acidity possible.

Key words: acidifying soils, primary liming, mobile Al

Introduction
The territory of Lithuania is located in the transitional climatic zone between maritime West European and continental East European and Asian. According to the hydrothermal conditions, Lithuania is located in the zone of excessive precipitation and moderate organic matter decomposition. (Buzas *et al.*, 1966). The mean annual air temperature is +6.2 ^{0}C, and the mean annual atmospheric precipitation constitutes 661 mm.
Areas with acid soils an mainly distributed in the eastern and western parts of Lithuania (Eidukevičienė, 1993; Eidukeviciene, Vasiliauskienė, 2001). Agricultural soils with a pH value below 5.5 have been regularly limed for several decades (1965-1990), resulting in a decrease in the total area of acid soils from 40.7 to 18.6 percent (Mazvila *et al.*, 2004).
With the period of economical changes, since 1991 the practice of soil liming significantly declined and has practically stopped at the present time. This led to the secondary acidification of limed soils and resulted in a negative effect upon crop production and the economics of Lithuania. The dynamics of agrochemical soil properties have changed in the 35 y. period passed since the primary liming analyzed in the current work. The restoration of soil acidity after regular liming are the stopping of naturally acid soils and the methods of evaluation of limed soil acidity are discussed.

Materials and Methods
Experiments were conducted at the Lithuanian Institute of Agriculture's Vokė Branch (located in latitude 54^{0}37´ North and longitude 25^{0}08´ East.) during 1972-2006. The experimental plots were established in sandy loam on carbonaceous fluvial-glacial gravel soil, *Haplic Luvisols* (LVh) according to the FAO-UNESCO classification. The depth of carbonate effervescence was 60–80 cm. It was a typical arable soil in the eastern part of Lithuania characterized by low organic matter