

Conclusions

Concerning the question of yield capacity of winter wheat the organic matter content in soil and the thickness of horizon Ap are of essential importance in the decision making system about the soil tillage differentiation.

The GIS cartograms allow site specific reduction of the basic tillage depth when the thickness of the horizon Ap is greater than 36 cm, which constituted 60.1 % of the total area of the experimental field.

At the GPS points with the average organic matter content 1.8 and 3.1 % the introduction depths of the seeds of winter wheat were respectively 3.2 and 3.7 cm ($P < 0.05$), and the variation coefficient of the sowing depth S % was respectively 9.2 and 16.9 %. This demonstrated that on the parts of the area with the organic matter content over 2 % and also the thickness of horizon Ap over 40 cm rolling down should be applied during the presowing soil tillage along with sowing.

The results of the variations of the penetrometric resistances of soil bore witness of their essential seasonality. The main factor of seasonality was the moisture of soil. The significant negative influence of increased resistance over 600 kPa cm⁻² (resistance being determined in spring) of soil under the arable layer was established on the yield of winter wheat.

It was established that deep loosening of soil should be carried out when the penetrometric resistance of soil exceeds 600 kPa cm⁻². The local GIS map allows reduction of the total amount of deep loosening of soil by 48 % of the entire area.

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NUTRIENT BALANCE AND AGROCHEMICAL PROPERTIES IN SOILS DIFFERING IN PHOSPHORUS AND POTASSIUM STATUS AS INFLUENCED BY FERTILISATION SYSTEMS

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Abstract

Experiments were conducted in 2001-2005 on sandy loam Calc(ar)i – Endohypogleyic Luvisol on two sites. The first site's soil was with higher amount of phosphorus and potassium (available P 0.082 – 0.108, available K – 0.093 – 0.136 g kg⁻¹), while the second site's soil was with lower amount of this nutrients (P 0.030 – 0.043, K – 0.067 – 0.093 g kg⁻¹).

The best nitrogen balance (close to 0) was achieved when nitrogen fertilisation rates were adjusted according to the mineral nitrogen content in soil in spring. When 60 t ha⁻¹ of manure were applied once per crop rotation cycle, negative nitrogen balance was calculated only for the plots not fertilised with nitrogen fertilisers. Nitrogen balance was negative when crops were not fertilised with manure and received average mineral fertilisation rates or the rates calculated using balance method, also in the case where winter wheat straw was ploughed-in once per crop rotation cycle. In spring mineral nitrogen content in soils of plots fertilised with different nitrogen fertilisation rates was quite similar. Mineral nitrogen content depended mainly on precipitation (0-40 and 0-60 cm – R = 0.66 and 0.71) and somewhat less on air temperature (R = 0.41- 0.45).

Fertilisation efficiency in soils rich in nutrients is low, and the excess of nutrients can be leached from soil into environment. In order to decrease the risk of environment pollution, the best solution is application of average phosphorus and potassium fertilisation rates adjusted according to the soil agrochemical properties and calculated using the balance method. When crops were fertilised with the rates calculated using the aforementioned methods, content of these nutrients in phosphorus and potassium rich soils almost did not change or tended to decrease, while in phosphorus and potassium poor soils content of plant available phosphorus and potassium increased.

Key words

Soil, fertilisation, balance.

Introduction

Productivity of agricultural crops can be improved by proper fertilisation. Setting of average mineral fertilisation rates for agricultural crops in Lithuania was based on the results of fertilisation experiments and biological peculiarities of particular crop. These rates are oriented towards achievement of average yields in cases when data on soil agrochemical properties and plant chemical composition are not available. From an economical point of view, especially in present conditions, sticking to these fertilisation rates is not always the best decision. In order to get the most optimal results, these rates are modified according to the amount of nutrients in soil: mineral nitrogen, plant available phosphorus and plant available potassium.

Researchers from different countries indicate the dependence of agricultural crops yield upon the amount of mineral nitrogen in soil (Kulakovskaja, 1974; Bogdevich, 1981; Becker and Aufhammer, 1982; Neeteson *et al.*, 1988; Mattson, 1990).

Efficiency of nitrogen fertilisers strongly depends on mineral nitrogen amount in soil: when it is very low, fertilisers are highly efficient (Pliupelyte *et al.*, 1995; Lazauskas *et al.*, 1996; Mengel, 1984; Vaisvila, 1996).

Lithuanian soils are grouped according to the mineral nitrogen amount, and different nitrogen fertilisation rates are set for each group. As the soil richness in nitrogen increases, the recommended nitrogen fertilisation rate decreases (Kulakovskaja, 1974; Vaisvila, 1996).

Amount of plant available phosphorus and potassium in soil affects the efficiency of mineral fertilisers too. Yet in this case a proper assessment of impact of nutrients available in soil on mineral fertilisers efficiency is necessary (Aovalsteinsson and Jensen, 1990; Greenwood and Karpinets, 1997; Mazvila *et al.*, 1996; Shiel *et al.*, 1997).

Time after time setting of agricultural crops' fertilisation rates is not based on the average rates, but calculated using a balance method taking into account a planned yield, demand of nutrients per unit of produce and employing the correction coefficients for uptake of nutrients from soil and fertilisers (Svedas, Tarakanovas, 2000).

Rather often Lithuanian growers fertilise agricultural crops in crop rotation systems with minimal nitrogen rates, and phosphorus and potassium fertilisers are applied only on very demanding crops – winter crops, hill-up crops, first-year perennial grass.

Humus amount in Lithuanian soils is low, therefore organic fertilisers are of high importance (Mazvila *et al.*, 1996; Mezals, 1997; Tripolskaja and Greimas, 1998). Animal husbandry has decreased substantially, thus less manure is accumulated. Ploughing-in of straw is another option for increasing of organic matter in soil (Bartashevich, 1987). Yet in this field more intensive research activities are needed. In this work we present the data on efficiency of winter wheat straw as fertiliser.

Aim of research – soil agrochemical properties and balance of nutrients in crop rotation systems set on nutrient-rich and nutrient-poor soils as affected by different crop fertilisation systems.

Materials and Methods

Experiment was carried out in 2001-2005 on sandy loam Calc(ar)i – Endohypogleyic Luvisols, with higher amount of phosphorus and potassium (with arable layer's pH_{KCl} – 4.8 – 5.3, available P 0.082 – 0.108, available K – 0.093 – 0.135 g kg⁻¹) and lower amount of this elements (pH_{KCl} 5.6 – 6.0, P – 0.030 – 0.043 and K – 0.066 – 0.093 g kg⁻¹).

Crop rotation system of five crops was set: perennial grass of first year use, perennial grass of second year use, winter wheat, potato, spring barley with undersown perennial grass.

Experiment was conducted using a single scheme: 1 variant – not fertilised; 2 – fertilised with PK, 3 – NP; 4 – NK, and 5 – NPK, average fertilisation rates applied, 6 – fertilisation rates less than in 5th variant by 25% for nitrogen, by 50% for phosphorus and by 40% for potassium; 7 – fertilised only with nitrogen; 8 – the rates applied in variant 5 adjusted to the mineral nitrogen, plant available phosphorus and potassium amount in soil, 9 – fertilised with manure, fertilisation rates calculated for the planned yield using a special computer programme created by A. Svedas and P. Tarakanovas, calculation is based on balance method (Svedas, Tarakanovas, 2000); 10 – NPK fertilisation rates calculated for the planned yield using balance method, nor fertilised with manure; 11 – agricultural crops fertilised only with average rates of mineral NPK fertilisers (no manure); 12 – winter wheat straw ploughed in together with 1 kg of N per 100 kg of straw. Rates of nutrients applied with incorporated straw: 19 kg ha⁻¹ of N, 3 kg ha⁻¹ of P and 14 kg ha⁻¹ of K in phosphorus and potassium rich soils, and 15 kg ha⁻¹ of N, 3 kg ha⁻¹ of P and 11 kg ha⁻¹ of K in phosphorus and potassium poor soils (Table 1). Besides that, in 2-9 variants plots destined for potato crop were fertilised with manure 60 t ha⁻¹ in autumn, resulting in average fertilisation rates 60 kg ha⁻¹ of N, 13 kg ha⁻¹ of P and 60 kg ha⁻¹ of K.

Table 1 Average annual fertilization rates for agricultural crops in field crop rotation, kg ha⁻¹

Treatment No.	Soil with higher amount of nutrients			Soil with lower amount of nutrients		
	N	P	K	N	P	K
1	0	0	0	0	0	0
2*	0	26	65	0	26	65
3*	51	26	0	51	26	0
4*	51	0	65	51	0	65
5*	51	26	65	51	26	65
6*	39	13	35	39	13	35
7*	51	0	0	51	0	0
8*	47	8	32	47	24	54
9*	29	5	24	12	20	33
10	50	6	40	26	24	51
11	51	26	65	51	26	65
12**	51	26	65	51	26	65

* incorporated 60 t ha⁻¹ of manure, **uploughed winter wheat straw

Soil samples were analyzed by the following methods: soil acidity (pH_{KCl}) – the electromeric; N_{min} – colorimetrically (N-NO₃ – using hidrasinsulphate and sulphanilamide, N-NH₄ – using sodium phenolate and sodium hyperchlorite; available phosphorus and potassium – AL. The total N in plant biomass was measured using Kjeldahl method; P – in vanadate-molibdate extraction and K – by flame photometry.

The data were processed by the method of dispersion analysis and correlative-regressive analysis. Statistical analysis has been carried out, using Microsoft Excel program.

Results

Nitrogen balance in soil was affected by amount of nutrients in soil and by the method used for calculation of mineral fertilisation rates. Nitrogen fertilisation rates in plots located on soil with higher amount of nutrients and not fertilised with phosphorus and potassium were only by 13.5 and 5.3 kg ha⁻¹, and in plots located on soil with lower amount of phosphorus and potassium – respectively by 17.4 and 19.9 kg ha⁻¹ higher than the nitrogen amount in crop yield. After having

adjusted the mineral NPK fertilisation rates according to the mineral nitrogen, plant available phosphorus and potassium amount in soil, nitrogen balance was about the same in both soils – with higher and lower amount nutrients: – 0.9 and 2.8 kg ha⁻¹ respectively. Calculation of fertilisation rates using balance method in most cases resulted in insufficient nitrogen fertilisation (Fig.1).

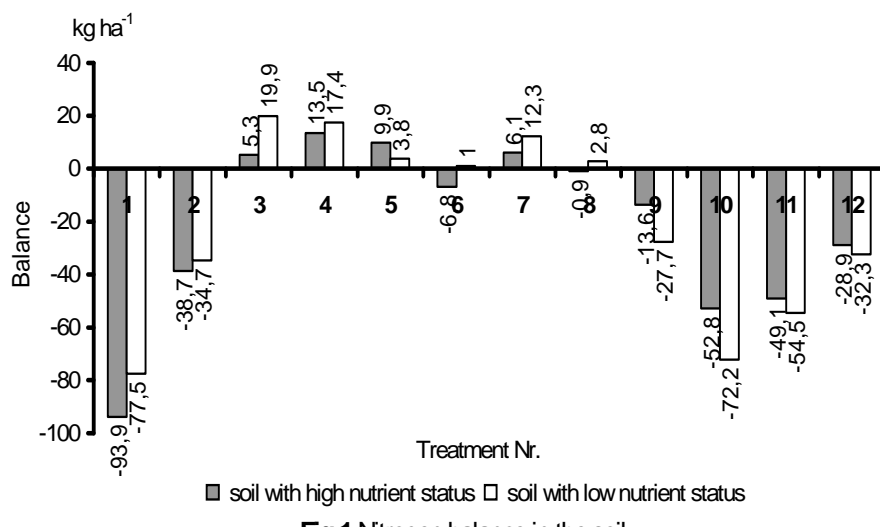


Figure 1. Nitrogen balance in the soil

Nitrogen balance was negative when crops were not fertilised with manure and received average mineral fertilisation rates or the rates calculated using balance method, also in the case where winter wheat straw was ploughed – in once per crop rotation cycle.

Mineral nitrogen amount in soils of different variants in spring was quite similar. According to the indices of regression equations, mineral nitrogen amount depended on mineral fertilisation less, than on air temperature (0-40 cm layer R = 0.45) and precipitation (0-40 and 0-60 cm – R = 0.66 and 0.71) (Table 2).

Table 2 The dependence of amount of mineral nitrogen in the soil (y) on two decades meteorological conditions (x)

Factors	Depth, cm	Equation $y=a+bx+cx^2$ coefficients			R	n
		a	b	c		
Air temperature, °C	0-40	7,20	0,303	0,000921	0,45	60
	0-60	6,50	0,284	-0,00253	0,41	60
Amount of precipitation mm.	0-40	13,07	-0,242	0,00270	0,66	60
	0-60	11,95	-0,238	0,00273	0,71	60
Nitrogen fertilizers rates, kg ha ⁻¹	0-40	9,51	0,00377	0,0000341	0,23	60
	0-60	8,48	0,00489	0,0000193	0,21	60

Phosphorus balance in plots fertilised with NPK fertilisers was positive almost in all cases; it depended on amount of nutrients in soil and on the method used for calculation of fertilisation rates. Crops fertilised with average NPK rates in soils with higher and lower amount of phosphorus it received (through application of mineral and organic fertilisers) respectively 23.9 and 24.4 kg ha⁻¹ of phosphorus more, than the amount of phosphorus accumulated in the yield (Table 3). Even application of decreased mineral fertilisation rates on the background of manure fertilisation resulted in excessive application of phosphorus – respectively 11.3 and 11.5 kg ha⁻¹ more than accumulated in plants.

Table 3 Effect of different fertilization systems on balance of available phosphorus in the soil and its amount

Treatment No.	Soil with higher amount of nutrients				Soil with lower amount of nutrients				
	Balance, kg ha ⁻¹	the amount of P in the soil			Balance, kg ha ⁻¹	the amount of P in the soil			
		2001	2005	±		2001	2005	±	
		g kg ⁻¹					g kg ⁻¹		
1	-12	0.082	0.084	0.002	-12	0.037	0.034	-0.003	
2	25	0.104	0.126	0.022	24	0.016	0.058	0.042	
3	24	0.106	0.122	0.016	26	0.043	0.057	0.014	
4	-1,8	0.092	0.090	-0.002	-0,9	0.031	0.038	0.007	
5	24	0.108	0.129	0.021	24,4	0.030	0.056	0.026	
6	11	0.090	0.104	0.014	11,5	0.032	0.039	0.007	
7	-1,2	0.086	0.087	0.001	-0,7	0.034	0.037	0.003	
8	5,3	0.096	0.102	0.006	21	0.030	0.055	0.025	
9	1,8	0.108	0.105	-0.003	19	0.033	0.046	0.013	
10	-8,6	0.103	0.099	-0.004	10	0.034	0.044	0.010	
11	12	0.101	0.110	0.009	11	0.034	0.050	0.016	
12	14	0.105	0.106	0.001	14	0.040	0.051	0.011	
LSD ₀₅		0.0137			0.0147				

After adjustment of mineral NPK fertilisation rates according to the soil agrochemical properties, positive phosphorus balance in soil with higher amount of phosphorus was 5.3; and in soil with lower amount of this element even 20.6 kg ha⁻¹. In case when phosphorus fertilisation rates were calculated using the balance method – 1.8 and 18.8 kg ha⁻¹ respectively. In the variant where winter wheat straw was ploughed-in once per crop rotation cycle and where average NPK fertilisation was applied, phosphorus balance was positive in both testing experimental fields, 14.2 and 14.0 kg ha⁻¹ respectively.

After crop fertilisation with phosphorus rates adjusted according to the soil agrochemical properties, plant available phosphorus amount in soil with higher amount of this element was about the same or slightly tended to decrease, and in soil with lower amount of phosphorus it increased by 0.025 g kg⁻¹. After fertilisation with average phosphorus rates, plant available phosphorus amount in soils of plots not fertilised with manure increased both in soils with higher and lower amount of phosphorus – by 0.009 and 0.016 g kg⁻¹ respectively, and where manure was applied – 21 and 26 mg kg⁻¹ respectively. Besides that, in soils of manure-fertilised plots increase of plant available phosphorus amount by 0.014 and 0.007 g kg⁻¹ was recorded even in plots fertilised with reduced mineral fertilisation rates.

Changes of plant available phosphorus amount in soil during the crop rotation cycle can be calculated using the regression equations presented in figure 2.

Changes of this element amount in soil during the crop rotation cycle strongly depended on the balance of this element (R = 0.85 – in soil with higher amount of phosphorus and R = 0.86 – in soil with lower amount of this nutrient).

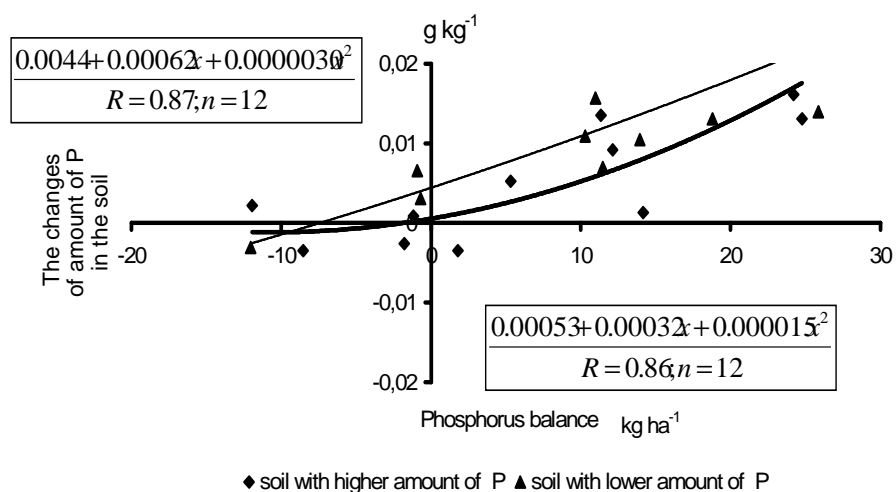


Figure 2. The effect of phosphorus balance on amount of mobile P in soil

In case of potassium balance the most appropriate crop fertilisation was achieved by application of mineral potassium fertilisation rates adjusted according to the soil agrochemical properties (Table 4).

After fertilisation of crops with potassium rates calculated using this method, the balance in soil with higher amount of potassium was close to 0, and in soil with lower amount of this nutrient – by 22.3 kg ha⁻¹ higher than the amount of potassium accumulated by crop yield. As a result of such fertilisation, plant available potassium amount in soil with higher amount of potassium almost did not change, in soil with lower amount of potassium it increased by 0.018 g kg⁻¹. When the average NPK rates were not adjusted according to the soil agrochemical properties, potassium supply was by 42.0 and 31.2 kg ha⁻¹ higher than the amount accumulated by yield, and the amount of plant available potassium in soil increased by 0.045 and 0.042 g kg⁻¹.

Table 4 The effect of different fertilization systems on amount of available potassium in the soil

Treat ment Nr.	Soil with higher amount of nutrients				Soil with lower amount of nutrients				
	Balance kg ha ⁻¹	the amount of K in the soil			Balance kg ha ⁻¹	the amount of K in the soil			
		2001	2005	±		2001	2005	±	
		g kg ⁻¹					g kg ⁻¹		
1	-76	0.093	0.089	-0.004	-65	0.090	0.076	-0.014	
2	38	0.130	0.168	0.038	34	0.078	0.119	0.041	
3	-24	0.112	0.100	-0.012	-17	0.085	0.080	-0.005	
4	60	0.132	0.184	0.052	42	0.089	0.125	0.036	
5	42	0.132	0.177	0.045	31	0.066	0.108	0.042	
6	8,1	0.105	0.123	0.018	9.2	0.075	0.083	0.008	
7	-26	0.103	0.110	0.007	-22	0.086	0.087	0.001	
8	1.4	0.132	0.136	0.004	22	0.081	0.099	0.018	
9	0,6	0.135	0.139	0.004	7.1	0.101	0.088	-0.013	
10	-46	0.120	0.125	0.005	-31	0.086	0.087	0.001	
11	-22	0.119	0.128	0.009	-26	0.072	0.087	0.015	
12	-6.2	0.120	0.113	-0.007	-13	0.080	0.085	0.005	
LSD ₀₅		0.0196				0.0169			

Potassium amount changes in soil can be expressed by regression equation (Figure 3). Correlation between the changes of plant available potassium amount in soils with higher amount of K and potassium balance – $R = 0.93$ in case of soil with lower amount of K – $R = 0.82$.

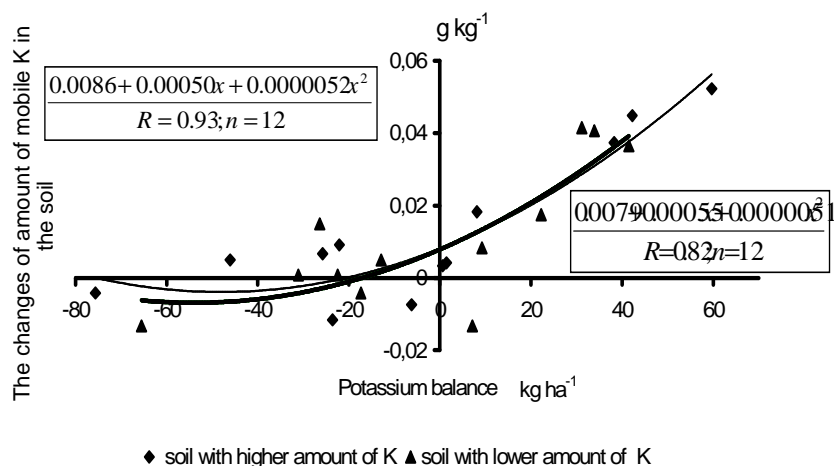


Figure 3. The effect of potassium balance on amount of mobile k in the soil

Organic fertilisers supplied the soil with large amounts of potassium. Application of average potassium fertilisation rates (without manure) (No.11), resulted in potassium supply deficiency: by 22.2 kg ha⁻¹ in soil with higher amount of potassium, and by 26.5 kg ha⁻¹ in soil with lower amount of this nutrient, when compared to the potassium amount accumulated by crop yield. Single application of 60 t ha⁻¹ of manure per crop rotation cycle changed the picture: in soil with higher and lower amount of potassium fertiliser-supplied potassium amount by 42.4 and 31.2 kg ha⁻¹ exceeded the potassium amount accumulated by crop yield (No.5). Ploughed-in straw also contains substantial amount of potassium, therefore a single ploughing-in of straw during the crop rotation cycle together with application of average potassium fertilisation rates make the good balance of potassium in soil (No.12).

Discussions

Developing countries – in order to supply more food to the people – are trying to improve the nutrients balance in soil and thus to slow down the decrease of soil fertility, while the developed countries are paying more attention to the protection of environment, especially to the increasing water pollution with phosphorus compounds and nitrates (Ishervood, 1998).

In our experiment the best nitrogen balance (close to 0) was achieved when nitrogen fertilisation rates were adjusted according to the mineral nitrogen amount in soil in spring. When 60 t ha⁻¹ of manure were applied once per crop rotation cycle, negative nitrogen balance was calculated only for the plots not fertilised with nitrogen fertilisers.

In order to increase the efficiency of nitrogen fertilisers and decrease environment pollution the amount of various nutrients supplied should meet the demand of crop. If phosphorus and potassium poor soils are fertilised only with nitrogen fertilisers, not only the crop yield is lower, but also the leaching of nitrogen compounds increases (Vaisvila, 1996; Goulding *et al.*, 2000). Because of this reason phosphorus and potassium balances are also important – there must be an optimal amount of these elements available in soil.

If soil is rich in nutrients, fertilisers' efficiency is low, and the surplus might be leached from the soil and become an environmental pollutant. According to the data obtained in our experiment, the best solution in such case is to apply average phosphorus and potassium fertilisation rates adjusted according to the soil agrochemical properties and calculated using the balance method. When crops were fertilised with the rates calculated using the aforementioned methods, amount of these nutrients in soils with higher amount of phosphorus and potassium

almost did not change or tended to decrease, while in phosphorus and potassium poor soils – increased. Application of 60 t ha⁻¹ of manure once per crop rotation cycle resulted in almost perfect phosphorus balance even in soils of plots not fertilised with potassium fertilisers; as for potassium – the balance was negative when the crop was not fertilised with potassium fertilisers.

After application of average NPK rates and ploughing-in of winter wheat straw phosphorus balance in soil was positive, as for nitrogen and potassium balances – the negativity was only partially compensated.

Conclusions

The best nitrogen balance (close to 0) was achieved when nitrogen fertilisation rates were adjusted according to the mineral nitrogen content in soil in spring.

When 60 t ha⁻¹ of manure were applied once per crop rotation cycle, negative nitrogen balance was calculated only for the plots not fertilised with nitrogen fertilisers.

Nitrogen balance was negative when crops were not fertilised with manure and received average mineral fertilisation rates or the rates calculated using balance method, also in the case where winter wheat straw was ploughed-in once per crop rotation cycle.

In spring mineral nitrogen content in soils of plots fertilised with different nitrogen fertilisation rates was quite similar. Mineral nitrogen content depended mainly on precipitation (0-40 and 0-60 cm – R = 0.66 and 0.71) and somewhat less on air temperature (R = 0.41- 0.45).

Fertilisation efficiency in soils rich in nutrients is low, and the excess of nutrients can be leached from soil into environment.

In order to decrease the risk of environment pollution, the best solution is application of average phosphorus and potassium fertilisation rates adjusted according to the soil agrochemical properties and calculated using the balance method. When crops were fertilised with the rates calculated using the aforementioned methods, content of these nutrients in soil with higher amount of phosphorus and potassium almost did not change or tended to decrease, while in soils with lower amount of phosphorus and potassium content of these elements increased.

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DATU STATISTISKO APSTRĀDES METOŽU PIELIETOŠANAS IESPĒJAS NEZĀĻAINĪBAS IZPĒTĒ STATISTICAL METHODS FOR ANALYSING THE DATA OF WEED FLORA

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Abstract

The ecological approach to the agriculture supports a conservation of biodiversity in agro-ecosystems. The biodiversity is a part of a well-balanced organic system and thereby ensures more stable yields of the crop. The diversity of vegetation within and around agro-ecosystem is an important component of biodiversity. Natural plants provide many animal species with a habitat and food resources. Therefore it is important to investigate the diversity of weed and their impact on ecological processes in crop fields, as well as on amount and quality of the yield. It is possible to use the same statistical methods for analyzing vegetation diversity of weed flora as in phytosociology. The methods, mentioned in this paper, have been used in agriculture only for last two decades in Europe. There are no similar investigations in Latvia. TURBOVEG is a comprehensive database management system designed for the storage, selection, and export of vegetation data – among them also weeds. Indicator values of Ellenberg characterize the ecological optimum of plants concerning climatic and edaphic factors. Two-way indicator species analysis TWINSPLAN and software JUICE can be used for the classification of weed flora. Direct and indirect ordination – CCA and DCA – can be used to find the main ecological factors that determine the variation in the data set. SPSS is now widely used in nature sciences and includes many possibilities of data analysis. MS Excel is suitable for analyzing small amount of data. Different statistical methods are characterised for analyzing vegetation data to determine their advisability for investigations of the diversity of flora in agriculture. To compare the results, using these methods it is useful for research of weeds in the fields of both systems of agriculture – organic and conventional.

Key words

Weed flora, statistical methods, organic agriculture

Ievads

Ekoloģiskā pieeja lauksaimniecībā atbalsta bioloģiskās daudzveidības saglabāšanu agroekosistēmās. Tā kā bioloģiskā daudzveidība ir daļa no labi līdzsvarotas organiskās sistēmas, kas, darbojoties saskaņā ar dabas procesiem, ir noturīgāka pret slimībām, tā nodrošina stabilāku laukaugu ražu. Veģetācijas daudzveidība ir nozīmīga agroekosistēmas un to ietverošās vides bioloģiskās daudzveidības komponente. Zviedrijā vairākas apdraudētas un retas sugas tika