SUMMARY

This monograph is dedicated to the 50th anniversary of the Agrochemical Research Laboratory of the Lithuanian Research Centre for Agriculture and Forestry; it includes the overview of the most important scientific research works and applied research works conducted during the last ten years of the activities. The results obtained from 22 different scientific research programmes are presented in this publication.

1. ACTIVITIES OF AGROCHEMICAL RESEARCH LABORATORY

This chapter presents a short description of agricultural soil research activities up to 2005, and a detailed description of the activities carried out during the period from 2005 to 2014.

1.1. Soil agrochemical research up to 2005. In this section the soil agrochemical research activities beforethe establishment of the Republican Agrochemical Laboratory, its development period and activities up to 2005 are described. Together with the development of soil agrochemical research activities methodology works, scientific research experiments, their topics , previous and present liming rate recommendations for acid soils are presented as well as the researchers that made the most significant contributions during that period are mentioned.

1.2. Agrochemical Research Laboratory in 2005-2014. This section describes the scientific research activities conducted by the institution, and the activities by the Analytical Research and Agrochemical Research Ddepartments.

1.2.1. Scientific research. Agrochemical Research Laboratory of the Lithuanian Research Centre for Agriculture and Forestry activities in this area encompass ongoing scientific research, field and laboratory experiments, writing scientific papers, research and development activities, publicizing the innovations in the field of scientific research, consultations and training. Over the last ten-year period of activities the Agrochemical Research Laboratory's researchers published 50 scientific papers and 58 popular and topical articles. Many of the written scientific papers were published in journals "Žemdirbystė=Agriculture" and "Žemės ūkio mokslai=Agricultural Sciences" in Lithuania, in "Archives of Agronomy and Soil Science", "Acta Agriculturae Scandinavica" and "Fertilizers and Fertilisation" – abroad. Thirteen recommendations were worked out over this period. The researchers of the Agrochemical Research Laboratory presented their research at international scientific conferences held in China, Italy, Ireland, Germany, Austria, Hungary, Poland and other countries. They participated as keynote speakers at scientific and industrial conferences, took active part in various professional discussions as well as in highlighting new problems, carried out training programmes and provided advice. The different scientific programmes implemented during the period of 2005–2014 can be divided into 10 groups: 1) research on fertilisation effects on crops and soil properties, 2) ecological research, 3) research on mineral nutrition of plants, 4) monitoring of soil agrochemical properties, 5) organic fertilizer research, 6) liming research, 7) research on soil degradation and prevention of pollution, 8) assessment of land productivity, 9) international programmes on the issues related with the use of agrochemical testing methods and 10) miscellaneous research activities.

1.2.2. Analytical activities in laboratories. The Analytical Department of the Agrochemical Research Laboratory is equipped with modern laboratories carrying out different kinds of analyses requested by scientists and by the customers from various economy sectors of Lithuania and foreign countries. The Department has implemented and continuously adhered to the quality assurance system in line with the requirements set in LST EN ISO 17025. The National Accreditation Bureau has accredited the Department in the fields of soil tests and active ingredient testing in plant protection products. The Analytical Department obtained the permission from the Environmental Protection Agency to test the wastewater, surface and ground water, soil, sludge, slag and dust for pollutants; a total of 170 quality parameters are tested. The annual number of orders for analytical testing during 2005–2014 increased from 2.8 to 4 thousand, and the annual number of analysed samples amounted to 38.6 thousand in 2014. The testing activities carried out in the Analytical Department are divided into six groups:

1. Soil tests: total and/or plant available concentrations of macro- and microelements, physical properties, pollution with heavy metals, persistent organic compounds and petroleum products.

2. Water and wastewater tests: almost all of the environmental indicators for water and wastewater set by the Environmental Protection Agency. This group of testing activities includes not only drinking, surface/ground water and wastewater tests, but also the tests of water used in heat exchangers, heating water, various solutions, lysimeter water collected by scientists, etc.

3. Plant, fodder and food of plant origin tests: the range of analyses performed in this group is very wide, covering chemical composition, biochemical parameters, pollution and physical properties. Food of plant origin is often tested for plant protection product residues and persistent organic pollutant concentrations.

4. Fertiliser, soil improvers and growth media tests: a large group of different products is covered here and the following tests are performed: total and/or plant available concentrations of macro- and microelements, contamination by heavy metals and persistent organic pollutants, physical and physicochemical properties as well as other quality indicators. A wide range of analyses is carried out in order to describe and evaluate these products, to assess their plant-nutritive value and intrusive contaminant properties.

5. Plant protection product tests: chromatographic analysis method is used, concentrations of active ingredients are identified and it is determined, whether the quality of plant protection product meets the requirements set for it.

6. Air pollution tests: the levels of heavy metals and persistent organic pollutants are measured in the dust of air filters.

The Department is performing many other kinds of analyses as well. Wood ash, fuel, waste, packaging tests are carried out. The clients are very diverse: scientists, farmers, agricultural companies, industrial and service companies, feed and feed additive manufacturing enterprises, state control authorities, companies exporting food of plant origin as well as supplying it to the domestic market, fertiliser manufacturing and selling companies, compost producers and users, biodegradable waste managing companies and greenhouse farms.

1.2.3. Agrochemical Research Department. The Agrochemical Research Department's staff is carrying out the scientific research activities across the country and at the same time introducing the results obtained into the agro-industrial sector. These activities include soil agrochemical research works on farms, mapping of nutrient content in tested soils, making liming and/or fertilisation plans, assessing of contaminated sites and crops, plant condition assessment using leaf tests, etc. The Department has developed a soil agrochemical research work technique consisting of four stages: 1) preparation of information on the fields to be assessed, 2) soil sampling, 3) laboratory tests and 4) preparation of recommendations. The Department uses a digital geo-spatial data set KŽS_DR10LT, a soil spatial data set Dirv_DR10LT, GPS devices, the accumulated previous soil agrochemical research data stored in the archives, digital mapping application *ArcGIS Desktop*, the office-developed methods and recommendations as well as an office-developed computer programme *Well-Balanced Fertilisation* which is based on the results obtained from more than 2,000 experiments and trials.

2. SOIL PRODUCTIVITY

This chapter outlines the main principles of the newly developed land productivity assessment methodology. The land productivity assessment tables and the stages of the assessment procedure are presented here as well. Particular attention is paid to the farmland soil productivity assessment conducted in Lithuania in 2014: the soils of Middle Lithuania municipalities received the highest scores, while the scores for less productive Eastern and Western Lithuania soils were much lower. The obtained land productivity data for all the country's cadastral areas and municipalities was divided into 5 groups:

I – soils of a very good economic value (up to 47.0 points) dominate. Districts: Šakiai (51.5), Jurbarkas (50.3), Pasvalys (50.0), Joniškis (48.7), Marijampolė (49.3), Kėdainiai (49.1), Kaunas (47.9).

II – soils of good economic value (42.1 to 47.0 points) dominate: Pakruojis (46.3), Radviliškis (45.4), Akmenė (44.6), Panevėžys (44.5), Biržai (44.2), Vilkaviškis (44.1), Šiauliai (44.1), Jonava (42.4), Kaunas city area (42.4), Raseiniai (42.2).

III – soils of moderate economic value (37.0 to 42.0 points) dominate: Mažeikiai (41.8), Kupiškis (41.5), Klaipėda city area (41.5), Kretinga (39.7), Tauragė (39.0), Kazlų Rūda (39.0), Ukmergė (39.0), Kaišiadorys (38.6), Prienai (38.1).

IV – soils of rather poor economic value (32.1 to 37.1 points) prevail: Širvintos (36.9), Birštonas (36.7), Alytus city area (36.6), Klaipėda (36.5), Kelmė (36.3), Anykščiai (36.1), Alytus (35.6), Pagėgiai (35.4), Vilnius city area (35.3), Kalvarija (35.3) Rokiškis (35.1) Švenčionys (33.9), Rietavas (33.8), Telšiai (33.6), Šilutė (32.8) Šilalė (32.5), Plungė (32.3), Šalčininkai (32.2).

V – soils of low economic value (less than 32.0 points) prevail: Vilnius (31.5), Elektrėnai (31.3), Molėtai (30.8), Druskininkai (30.5), Varėna (30.4) Utena (30.2) Zarasai (29.9), Trakai (29.2) Visaginas (27.6).

Considering the fact that the soil cover in the country varies widely and soil properties as well as land productivity are not the same in the most of the cadastral areas within different municipalities, the newly obtained land productivity evaluation data calculated for each municipality was presented, analysed and discussed. The most important factors affecting the soil productivity score were rated: soil type and texture, pH group, group of richness in plant available phosphorus and potassium, land cover diversity, etc. The description of properties of soil types dominating in different administrative districts is based on the classifications set by LTDK-99 and PTO-96.

This new land valuation data including a breakdown of it into soil productivity groups and explanation of the results obtained will be used by agricultural producers, the Advisory Service, researchers, territory planning administrative authorities and land market operators. The most suitable soil to grow crops should be chosen on the basis of the available data on soil productivity score, which enables forecasting of crop productivity and provides the necessary information for fertilisation and liming planning.

3. SOIL EROSION

This chapter presents the results of research conducted in Lithuania on typical water and wind erosion cases and the possibility to use empirical models for the evaluation of water erosion.

3.1. Typical water erosion cases. 9 sites were chosen as typical areas of water erosion: Žemaičiai Upland – Burniai, Jankaičiai and Gineikiai, eastern part of the Baltic Upland – Gražavietė, Dapkūniškis and Laumėnai, Southeast Lithuania (Dzūkai Upland) – Domantonys, Daugai and Drabužninkai, Middle Lithuania Lowland (Kėdainiai district) – Sičioniai and Mantviloniai. The distribution of eroded soils was assessed using the maps of 1:10,000 in accordance with the TDV-96 and LTDK-99 classifications, as well as the texture, eroded soil slope variation, the average gradients of eroded slopes, crops grown and the cropping pattern. The amount of soil carried away was calculated using the Rusle module. The value of production was assessed as well as production costs, pollution reduction and production costs per one percent of pollution reduction.

Depending on intensity of the occurrence of erosion, different agro-technical measures should be applied. The most important of them is growing of grasses.

3.2. Typical wind erosion cases. Three sites were chosen as typical areas of wind erosion: 1) Rūdiškės in Trakai district, 2) Juknaičiai in Šilutė district and 3) Drukiai near Priekulė in Klaipėda district. The amount of soil carried away by wind from the bare fallow was measured using A. Račinskas equation. The wind speed was considered to be critical when it was greater than 5 m s^{-1}. The data collected from the meteorological stations in Lithuania during the 1993–2002 period and the data on the annual duration of wind of different speed was used as well.

Our theoretical calculations revealed that the annual amount of soil carried away by wind from sandy fields without plant cover in different locations of Lithuania varies considerably – from 3.5 to 32.9 t ha^{-1}. The theoretical annual loss of soil from bare fallow fields located in windy places can be up to 30 t ha^{-1}, and only seldom, once in 3–4 years conditions for wind erosion can become particularly favourable – dry soil, no plant cover, wind speed 15–20 meters per second – and the amount of soil loss can reach 8–20 t ha^{-1} and more.

3.3. Use of empirical models for assessment of water erosion in Lithuania. The assessment of water erosion intensity in Lithuania so far has been based mainly on the data obtained from the actual measurements conducted on special research sites. We have analysed the results from multiannual experiments carried out at the Kaltinėnai Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry, assessed the eroded areas of 14 typical sites representing different regions and made calculations using different empirical models (PESERA, USLE, RUSLE and others). It appeared that the results obtained using RUSLE model were the most similar ones (R^2 – 0.79) to the actual experimental data. RUSLE model equation: $A = (R + R_s) \times K \times SL \times C$, where A – amount of lost soil, R – rainfall erosivity factor, R_s – factor of water reserves in snow, K – erosivity factor of soil properties, SL – slope length and gradient factor and C – cropping management erosivity factor.

Lithuanian researchers have accumulated significant amounts of detailed information on Lithuania's soils; therefore, it is proposed to supplement the RUSLE model for Lithuanian conditions with D_E factor for assessment of eroded soil areas within the soil contour.

An average annual soil loss caused by erosion depends on the intensity of erosion: a) fields fully exposed to erosion – more than 80 t ha^{-1}, b) eroded areas prevail – from 41 to 80 t ha^{-1}, c) high prevalence of erosion – 11–40 t ha^{-1}, d) average prevalence of erosion – 2–11 t ha^{-1} and e) low erosion prevalence – up to 2 t ha^{-1}.

4. SOIL AGROCHEMICAL PROPERTIES

This chapter presents the results of 10 scientific research programmes – indicators of soil agrochemical properties, their variation, dependence on the environment and anthropogenic factors, methodology works, etc.

4.1. pH variation. Research objective was to determine pH distribution and variation in the soils of different regions compared with the previous research results.

The newest agrochemical test results showed that nonacidic (pH > 6.0) soils prevailed in arable land of Middle Lithuania and 25.0% and 39.5% of the investigated land area in Eastern and Western Lithuania accounted for acidic (pH ≤ 5.5) soils. As ten years ago, the most acidic soils were recorded in Varėna (65.6%), Šilutė (63.0%), Plungė (55.9%) and Šalčininkai (52.5%) districts, a considerable part of them is also registered in Klaipėda (46.7%), Telšiai and Vilnius (43.1% in each) districts. The relatively smallest part of acidic land areas can be observed in Joniškis, Pakruojis and Akmenė districts. The research data allows forecasting that failure to lime acidic soils will result in the increase of slightly acidic soils and the decease of near-neutral soils.

4.2. Observation of mineral nitrogen variation. The objective was to determine the content of mineral nitrogen (N_{min}) in the soils of different regions of the country in spring and establish consistent patterns of its accumulation. The research results of 2005–2014 indicated that in spring the average mineral nitrogen content at the 0–60 layer in sands accounted for 45.9 kg ha^{-1}, sandy loams – 53.1 kg ha^{-1}, light loams – 61,2 kg ha^{-1}, and in clay loams, clays and silty loams it amounted to 62.1 kg ha^{-1}.

4.3. Distribution of mobile phosphorus. The research objective was to determine the content and variation of mobile phosphorus in Lithuanian regions. Having summarized the 1999–2013 and previous data of soil agrochemical investigations it was established that the content of mobile phosphorus increased in the majority of Lithuanian soils. The exception was western and southern parts of Lithuania, which demonstrated considerable (9.4% and 5.9%) increase of very low phosphorus soils. In the majority of soils (19.3% and 33.3%) investigated in certain country's locations demonstrated very low (<50 mg kg^{-1}) and low (51–100 mg kg^{-1}) contents of mobile phosphorus; and in 20.9% – average (101–150 mg kg^{-1}) contents.

Phosphorus content in the soils of the country's regions is uneven. Middle Lithuania's soils with high and very high (>200 mg kg^{-1}) contents of this element accounted for 22.2% and soils with very low mobile phosphorus contents (<50 mg kg^{-1}) – only 4.4% of investigated area. In Western Lithuania the soils with low phosphorus (51–100 mg kg^{-1}) contents account for one third (33.7%) and in Eastern Lithuania they marginally exceed one fifth (21.9%). In Western Lithuania the highest percentage of soils with low phosphorus contents was established in Skuodas (88.6%), Mažeikiai (80.4%), Plungė (75.6%), Šilalė (75.3%), Klaipėda (73,2%) and Telšiai (72.4%) districts; in Eastern Lithuania – in Molėtai (72.3%), Kupiškis (69.8%), Utena, (68.9%), Anykščiai (68.2%), Zarasai (66.5%) and Ukmergė (65.9%) districts.

4.4. Distribution of mobile potassium. The content and variation of mobile potassium in Lithuanian regions was investigated. It was established that the contents of mobile potassium are higher in the soils of investigated districts compared with mobile phosphorus. Soils with average contents of mobile potassium prevail which account for 42.0% of the investigated agricultural land. Soils with very low and low potassium contents accounts for 15.8% of the investigated area, and 11–19 years ago they comprised 26.8%. Systematic fertilization of plants with potassium resulted in a consistent increase of it in the majority of regions. This element decreased only in those areas, where light-textured soils prevailed or plants were scarcely fertilized with potassium.

High potassium contents can be observed in Middle Lithuania soils; very low (<50 mg kg^{-1}) and low (51–100 mg kg^{-1}) contents of this element is typical only for 0.5% and 10.9% of soils. In Western and Eastern Lithuania soils with very low and low contents of potassium account for approximately one fifth (20.3% and 18.5%) of the area investigated. In Middle Lithuania potassium contents in soil increased most in Joniškis (35.6%), Kėdainiai (30.3%) and Kaunas (28.9%) districts, the decrease was observed in Panevėžys (17.9%), Šiauliai (5.6%) and Prienai (5.5%) districts. In Eastern Lithuania the contents of this element increased most in Kaišiadorys (31.2%), Rokiškis (24.1%) and Alytus (19.4%) districts, and decreased in Trakai (19.0%), Vilnius (16.5%) and Švenčionys (15.0%) districts. In Western Lithuania the highest increases of mobile potassium were registered in Raseiniai (24.0%), Šilalė (18.9%) and Skuodas (8.0%) districts, and decreased in Telšiai (18.9%), Mažeikiai, Kelmė (17.6% in each) and Klaipėda (15.1%) districts.

4.5. Content of mobile magnesium and determination methods. The objective of this research was to determine the content of mobile magnesium in soil while applying different extractants. According to the research data the highest values of mobile magnesium were established while applying A-L method, when the mean value of magnesium content in arable layer accounted for 655 mg kg^{-1} and variation interval was 96–4210 mg kg^{-1}. Much lower contents of mobile magnesium were established using other research methods. Estimations while applying calcium chloride, potassium chloride, ammonium acetate and Mehlich 3 methods yielded low variations between magnesium values and arithmetic means were 187–292 mg kg^{-1}s. In water extract, the minimal and maximal values of mobile magnesium were 9 and 96 mg kg^{-1}.

6. Influence of long-term fertilization on variations of plant nutrition elements. The objective of long-term research carried out in Skėmiai, Radviliškis distr. was to estimate variation of soil agrochemical properties while fertilizing with different rates of nitrogen, phosphorus, potassium and their interaction. Having estimated dependence of *mineral nitrogen* present in the 0–30, 30–60, 60–90, 0–60 and 0–90 cm soil layers in spring on long-term fertilization of agricultural plants with mineral fertilizer; strong and significant relationship was established as well – R = 0.92–0.95.

In spring the content of *mineral sulphur* in the 0–60 cm layer depending on fertilization was 11 kg ha^{-1} ($N_{111}P_0K_0$ fertilization treatment) to 107.9 kg ha^{-1} ($N_{222}P_{192}K_0$ fertilization treatment), and in the 0–90 cm layer it was 18.0 to 176.3 kg ha^{-1}, respectively.

It was established that systematic long-term (44 years) fertilization of plants with mineral fertilizers resulted in significant (R = 0.93) dependence of *mobile phosphorus* content in soil on phosphorus fertilizer rates and its interaction with nitrogen and potassium rates. Regression equation parameters indicate significant positive influence of phosphorus fertilizer on the content of mobile phosphorus in soil.

Plants assimilate more *mobile potassium* from soil compared with phosphorus. Having calculated dependence of mobile potassium in soil in terms of interaction between fertilizer rates and plant nutrition elements a strong (R = 0.92) correlation was obtained. The content of mobile potassium mainly depended on the rates of potassium fertilizers; however, substantial influence was exerted by nitrogen and phosphorus fertilizers which stabilized the variations of mobile potassium in soil. After the last rotation had been completed the lowest content (83–92 mg kg^{-1}) of mobile potassium in soil was established, when plants were growing without fertilizers for a long time; the highest content (266 ir 308 mg kg^{-1}) was recorded after having fertilized the plants with high rates of nitrogen and phosphorus fertilizers without phosphorus fertilizers ($N_{222}P_0K_{192}$) or high rates of phosphorus and potassium fertilizers without nitrogen fertilizers ($N_0P_{192}K_{192}$).

4.7. Content of mineral sulphur. The objective of eight-year observation research on mineral sulphur (S_{min}) content in soil was the estimation of its content and accumulation regularities in different regions. It was established that the content of mineral sulphur in soil varies depending on a particular year and it is influenced by soil texture, humus content, air temperature, plants cultivated and fertilization.

Research evidence suggests that mineral sulphur contents in Western and Eastern Lithuania are lower compared with Middle Lithuania. In the 0–60 cm layer of the soils in these zones they were 14.2, 14.7 and 17.3 kg ha^{-1}, respectively. Although during observation the influence of different factors on the amount of mineral sulphur varied; however, the average data of 2007–2015 suggested that the mineral sulphur content in the 0–60 cm layer in sandy soils was 12.9 kg ha^{-1}, that in sandy loams was 14.1 kg ha^{-1}, loams – 16.4 kg ha^{-1}, and clay loams and clays – 18.3 kg ha^{-1}.

4.8. Humus content. Research evidence showed that its content in the arable layer of mineral soils most often amounted to 0.7–4% in peat and more than 20% in muck soils. One third of soils in Lithuania have very low and low contents of humus. The lowest contents of humus are observed in arable land soils of Eastern Lithuania zones. In Middle Lithuania only 20% of soils have low humus contents and high and very high humus content soils account for 32.9%. In Western Lithuania soils of low and average humus content are distributed more or less equally and account for nearly three quaeters of the total regional area.

4.9. Methods of sample taking for soil pH tests and geostatistical data analysis. The objective was to identify the most appropriate method for taking samples from Lithuanian soils of different genesis and relief for pH tests as well as to estimate spatial dependence of data and interpolation possibilities.

Taking account of research results, it is recommended to take samples from limed areas considering the boundaries of soil types and pH groups identified during previous investigations, and in case recent pH testing data is not available – considering soil type boundaries: from 8 ha of level relief areas, from 4 ha of rolling relief when soil cover is less varied, and from 2 ha plots when soils are more varied. It is recommended to take samples from 2–4 m^2 sites in hilly relief areas, in which eroded and non-eroded soils alternate, while establishing the ratio of limed soils.

4.10. Assessment of research methods of soil agrochemical properties and fertilization recommendations in Central and Eastern Europe. Methods applied by the laboratories of Eastern and Central European countries for the research of soil agrochemical properties are not the same: one of four available methods (A-L, D-L, Me 3 or CAL) is chosen for determining mobile phosphorus and potassium contents, and one of two methods (KCl or $CaCl_2$) – to determine pH index. Mobile magnesium in soil can be determined by four methods – KCl, $CaCl_2$, A-L or Me 3. Each state has validated its own methods for the research of soil agrochemical properties and the assessment of obtained results. The recommendations provided on fertilizing agricultural plants and advocated by different countries indicate that the approaches to the assessment of research results and fertilizer effect are not uniform in individual states.

5. OPTIMIZATION OF AGRICULTURAL PLANT NUTRITION

5.1. Relationship between agricultural plant yield and nutrition and soil agricultural properties. In a long-term fertilization experiment on mineral fertilizer effect on soils of different phosphorus and potassium contents carried out in Elmininkai, Anykščiai distr. It was established that during two crop rotations, when plants had not been fertilized, the metabolizable energy accumulated in the soils of higher phosphorus and potassium contents amounted to 4.3GJ ha^{-1} on average and with NPK fertilization – 6.8 GJ ha^{-1} more than achieved in the soils of lower phosphorus and potassium contents. The most efficient was nitrogen fertilizer that increased metabolizable energy content by 14.4–16.9%. Due to phosphorus fertilizer effect metabolizable energy content increased by 6.7–7.9% and due to potassium fertilizer it increased by 7.5–8.3%. Organic fertilizer was more efficient in increasing metabolizable energy content in crop rotation plants (3.8GJ ha^{-1}) in the soils of lower phosphorus content compared with higher phosphorus and potassium content (1.8GJ ha^{-1}) soils.

5.2. Effect of organic fertilizers on agroecocenosis and nutrient dynamics. Research data indicates that organic fertilizer Biofer and bone meal were almost equally efficient for agricultural plants: spring wheat yield increased by 32.5–35%, winter rye – by 21.8–28.1%, potato tubers – 15.7–17.8% and the yield of red clover green mass increased by more than 30%. Due to the effect of this fertilizer pH, mineral nitrogen, mobile phosphorus and potassium contens in soil varied, and nitrate concentration in lysimeter waters was marginal and accounted for 13.6–15.6 mg l^{-1}.

5.3. Variations of agricultural plant yields depending on interaction between nutrient elements. 44-year (1971–2014) data of the experiments carried out in Skėmiai, Radviliškis distr. was presented in order to establish plant yield and quality variations depending on the interaction between basic nutritious elements (N, P and K).

Having summarized the experimental data it was established that the efficiency of basic nutritious elements (N, P, K) reaching plants with mineral fertilizers highly depended on their interaction. All yield supplements achieved from experimental plants, except annual grasses, were 2.0–2.5 times higher due to nitrogen and phosphorus fertilizer effect caused by the interaction between nitrogen and pshopshorus or between phosphorus and nitrogen with potassium. Due to the effect of potassium fertilizer caused by its interaction with nitrogen and phosphorus, yield supplements were 2.5–3.0 higher compared with the supplements obtained from fertilizing with monomial fertilizer.

5.4. Leaching of anions and cations from soil due to long-term fertilization. According to the long-term (1976–2011) data of the experiments carried out in Skėmiai, Radviliškis distr. major leachings from soil include sulphates and nitrates, substantially lower leachings include chlorides and very low leachings are typical to phosphate anions. While estimating cation leaching to the 40 cm soil depth it was established that the highest amounts leached from soil are those of calcium, lower amounts were those of magnesium, nitrogen and potassium accounted for significantly lower amounts and the lowest amount leached was that of ammonium.

5.5. Effect of magnesium fertilizer on agricultural plants. Research evidence suggests that Mg_{20} rate increased spring barley yield significantly only in soils of low carbonate content and the achieved grain yield supplement amounted to 4.4% on average. Irrespective of soil carbonate content magnesium fertilizer significantly increased the amount of crude proteins in grain and straw as established by numerous experiments.

Magnesium fertilizer significantly increased the yield of common ryegrass in a hot year. Correlation was established between common ryegrass yield and the contents of mobile magnesium, calcium, carbonates and humus in soil.

5.6. Effect of dolomite powder in neutralizing acid soils and peat. Two experiments were carried out at the experimental site of the Agrochemical Research Laboratory. Research objective was to establish how different rates of dolomite powder affect pH value of peat and acid soils compared with other liming materials.

The data obtained from experiments suggests that while neutralizing acidic soils and peat the effect of liming materials is very unequal after the first days of liming and following two months, it also depends both on type and especially on coarseness of materials.

5.7. Assessment of compost materials and quality. According to research data raw materials used for compost production and the composts produced are of very irregular quality. It was suggested to assess compost quality by two indicators – in terms of compost safety and the quality of compost as a fertilizer.

It is suggested to assess compost safety by undesirable substances – amounts of plastic, glass, metal and stones – present. The assessment should also take account of the amounts of cadmium (Cd), lead (Pb), mercury (Hg), chromium (Cr), zinc (Zn), copper (Cu), nickel (Ni), arsenic (As) and organic pollutants (PCBs and PAHs) as well as phytotoxicity, the amounts of microbial and parasitic disease causative agents and plant pathogens.

The main quality indicators of compost as a fertilizer should be: pH_{KCl}, dry and organic matter, total nitrogen, phosphorus and potassium, electricl conductivity, water soluble nitrogen and/or mineral nitrogen, water soluble phosphorus and potassium, and C and N ratio.