

SHORT COMMUNICATION

A Monitoring study of soil fertility in the agricultural area of rivne region of Ukraine

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Abstract

Agroecological assessment of soil of Rivne region was conducted. Stabilization of main nutrients in the soils of the farmland of Forest-Steppe zone, due to the minimization of tillage, increased use of fertilizer, use tools of agriculture biologization as primarily plowing of straw, stalks and other crop residues and green manures, is shown. At the same time there is a downward trend in these indicators in soils of Polissya. The reduction mobile phosphorus and exchangeable potassium in soils of Polissya is associated with the decreasing use, in these areas, of organic and mineral fertilizers. Weighted average phosphorus content in Rivne region equals 125.3 mg/kg of dry soil; weighted average exchangeable potassium content equals 71.0 mg/kg of dry soil. The negative dynamics of soil acidity is shown. Areas with high acidity soils increased. Now they occupied 39.3 % of the farmlands of the Rivne region. Sharply reduced availability of microelements in soil, due to the reduction of use of organic and mineral fertilizers on the territory of Rivne region, especially in Polissya, is shown. Recommendations for conservation and increasing of soil fertility of Rivne region are proposed.

Key words: Soil, Agroecological condition, Land protection, Monitoring, Soil fertility

Introduction

Most of the territory of Rivne region is typical for Western Polissya (KM, Resolution N 2068, 1998). Western Polissya (Polesie) includes the western part of the Republic of Poland (Bialystok, Lublin Voivodeship), northern part of the Republic of Belarus (Brest region), southern part of Ukraine (Volyn region, Rivne region). The total area of the Western Polissya is 51 thousand km² (Alicja Breymeyer, 2014).

The value of land as a primary means of agricultural production is determined by soil fertility. Now when the human impact on the land becomes more tangible and intense, the problem of preservation of soil fertility becomes more important. Today the human impact on soil causes their degradation, resulting in decreased productivity of agricultural land.

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To ensure sustainable development much of the attention are given recently to the problem of soil degradation worldwide, due to the intensity of the manifestation of these processes and to the importance of preservation the structural and functional characteristics of groundwater systems (Bulygin et al., 2008; Lykov and Shestakov, 2005; Tikhomirov et al., 2003; Furdychko et al., 2006; Buckmann and Lee Ylong Heui, 2008).

Monitoring is an essential part of the development of the State Strategy of agricultural production. Soil Monitoring as an important part of Soil Management can be achieved through soil testing. Soil testing helps to determine the fertility of soils and can help to assess potential needs of soil in fertilizers, lime or gypsum. Monitoring of the agrochemical characteristics can be very useful instrument to improve quality of crops and pastures in agriculture.

Pursuant to Presidential Decree "On solid agrochemical certification of agricultural land", Laws of Ukraine "On Protection of Land", "On State Control over Land Use and Protection", "On Land Reclamation", "On the Fundamentals of State Agricultural Policy until 2015 year", "On Amendments to some legislative acts to preserve soil fertility" and Order of President "On Approval

of the Monitoring of soil on agricultural land" there is need for agrochemical certification of all agricultural land, including in the Rivne region.

Agrochemical investigation and certification of all agricultural land in all Regions of Ukraine are provided, including solid soil investigation by agrochemical, toxicological and radiological indicators. The most important is determination of the content of soil humus, mobile phosphorus, exchangeable potassium and reaction of soil solution.

Definition of agro-chemical parameters makes it possible to set the status of soil fertility and its changes and to develop measures to protect soil from degradation processes. Due to results of agrochemical investigation of soil, highly effective technologies of fertilizer application, optimization of their dose, timing and methods of application as well as chemical reclamation for liming of acid soils have been developed and implemented. Analysis of soil on the content of microelements helps to develop Guidelines on the use of microfertilizers. According to the agrochemical and toxicological analysis of soils, cartograms of content of nutrients and various types of pollutants have been made.

The aim of this work was to establish the factors of maintaining and improving of soil fertility of agricultural land in Rivne region. In order to fulfil the requirements of Article 54 of the Law of Ukraine "On Land Protection", Article 9 of the Law of Ukraine "On State control over land use and protection", data of State Institution "The Institute of Soil of Ukraine" on agrochemical investigation and certification of agricultural lands during 1986 -2010 years were analysed.

Materials and Methods

During the work on ecological and agrochemical certification of agricultural land, standard methods were used (Sozinov and Prister, 1994; Sozinov, 1996; Ryzhuk et al., 2003). Field agrochemical investigation of agricultural land, sampling and laboratory testing of soil samples were performed according to the State Standards of Ukraine (DSTU) and International Standards (GOST, ISO) acting in Ukraine and existing methods. In selected samples agrochemical indexes were determined.

Analysis of soil samples was performed on an Automated line "ASVA-P(k)" according to Existing Standards in Ukraine: determination of pH was carried out according to GOST 26483-85 by method, for pH determining of salt extraction in soils; determination of mobile compounds of

phosphorus and potassium was conducted on the following methods: Kirsanov method (DSTU 4405:2005) and Machyhin method (DSTU 4114-2002); samples of carbonate soils were determined by the Machigin's method, using extraction with 1% $(\text{NH}_4)_2\text{CO}_3$ solution.

Alkali hydrolysed nitrogen was determined by Guidelines, on determination of the alkali hydrolysed nitrogen, in the soil, by the Kornfeld method (Gorodny et al., 2005), based on hydrolysis of organic compounds of soil solution, using sodium hydroxide; evaporated ammonia is absorbed with boric acid in Conway glassware and is titrated with sulfuric acid. Determination of humus was made by the Tyurin method (DSTU 4289:2004) by oxidation of humus in soil with potassium dichromate in sulfuric acid media using heating with next photocolometric measuring.

Mobile compounds of cobalt, copper, manganese in soils were determined by the Peive and Rinkis method modified by CINAQ: cobalt (GOST 50687-94) was determined in 1N solution of nitric acid; copper (GOST 50684-94) – in extraction of 1N hydrochloric acid; manganese (GOST 50682-94) for all types of soils, except carbonate soils – in 0.1N solution of sulfuric acid, with the following determination on atomic absorption spectrophotometer C- 112. Content of zinc was determined by the Krupsky and Alexandrov method (GOST R 50686-94). Determination of mobile boron was conducted in accordance with GOST 50688-94 by the Berger and Truoh method (boron extrusion with hot water and obtaining a colored complex of boron and azomethine and followed using of photocolometric determination of solutions). Hydrolytic acidity was determined according to the GOST 26212-91, by the Kappen method. The soil was treated with 1N solution of sodium acetate, with the subsequent determination of acidity in suspension.

The base absorption sum was determined according to the GOST 27821-88 by bases extrusion from soil by 0.1N HCl, with following titration with 0.1 N NaOH solution. The amounts of exchangeable calcium and magnesium were determined according to GOST 26487-85, in 1N KCl extraction, by the method of complexometrics titration (calcium and magnesium are titrated with Trilon B). Soluble in an acid solution forms of heavy metals (lead, cadmium, zinc, copper) were determined on an atomic absorption spectrometer S-115-M. Metals were removed with 1N HNO_3 solution, according to the Methodical Guidelines

for Determination of heavy metals in soils of arable lands and crop production (1989).

Mercury was removed from the soil with a mixture of concentrated HCl and H₂SO₄ and determined in accordance with the instructions of the certified in Ukraine device "Julia". ¹³⁷Cs was measured by the spectrophotometric method, on gamma spectrometers SEG- 1 (EVT-SP +) and AMA-03F, with a scintillation detector in liter Marinelli vessels with exposure times of 1 hour; ⁹⁰Sr was measured by radiometric method and classical oxalate method with subsidiary yttrium-90 according to Derzhavin (1985).

Results and Discussions

The total area of the Rivne region is 2005.1 thousand hectares, of which 46.4% is agricultural land, 40.1% are forests and other wooded areas, 2.9% is built-up land, 5.2% is open wetlands land, 1.6% is open land without vegetation or slightly covered by plants, 2.2% of the territory is under water, 1.6% other lands. In the structure of the lands, the greatest values on influence on the environment have agricultural lands. In the structure of agricultural land there are 32.8% of arable land, 0.2% of fallow, 12.9% of meadows and pastures and 0.6% of land with perennial plants.

In recent years, from the beginning of January 1, 2008, the structure of Land Fund of Rivne region has changed. The area of arable lands was decreased by 3.9 thousand hectares, including 0.4 hectares of arable land, hayfields, pastures and fallow lands and other types of lands. Area of forest and other forest covered areas were increased by 2.3 thousand hectares, area of built-up land was increased by 2.9 hectares and area of open wetlands was increased by 0.6 hectares.

Agrochemical certification of agricultural land

During the period of Round IX (2006-2010) of Agroecological Monitoring (inspected area is 570.1 hectares), 116.96 thousand of soil samples were selected, and investigation was conducted in 343 village councils and 355 households, of which 187 are farms. 503.75 thousand tests on 16 indicators were performed. Agrochemical cartograms of the area of 570.1 thousand hectares were created; 13.575 thousand of agrochemical passports were developed.

The largest areas of investigated agricultural land were in Mlyniv District (58.5 thousand hectares) and in Dubno District (56.9 ha areas); in these Districts 12.66 and 12.2 thousand samples were taken. The smallest investigated areas were in Demydivka District (15.0 hectares) and

Zdolbuniv District (21.5 hectares); in these Districts 2.64 and 4.55 thousand samples were selected respectively.

The reaction of the soil solution

The reaction of soil solution plays an important role in the development of plants and soil microorganisms, affects the rate and direction of flow of chemical and biochemical processes in soil solution. Assimilation by plants of the nutrients, the intensity of microbial activity, mineralization of organic matter, decomposition of soil minerals and dissolution of various hard-soluble compounds, coagulation and peptization of colloids and other physical and chemical processes largely determine the response of the soil (Melnychuk et al., 2004; Gorodny, 2008). Acidic soil reaction is related to the unfavourable environmental factors that inhibit the growth and development of most crop species. Acidic reaction is typical for sod-podzolic and bog soils, while neutral reaction is typical for chernozem. All crops differently related to the degree of acidity of the soil, as a culture has a pH range at which it is growing and developing well. According to Round IX of Agroecological Monitoring, soils of Rivne region can be divided on acidity into the following groups: very highly acidic and highly acidic (pH less than 4.6) soils, area of which occupies 68.9 hectares (12.1%); medium acidic (from 4.6 to 5.0) soil, area of which occupies 79.8 hectares (14.0%); slightly acidic (from 5.1 to 5.5) soil, area of which occupies 75.7 hectares (13.3%); close to neutral (from 5.6 to 6.0) soil, area of which occupies 77.1 hectares (13.5%); neutral soil (from 6.1 to 7.0), area of which occupies 157.9 hectares (27.7%); slightly alkaline soil (from 7.1 to 7.5), area of which occupies 100.3 ha (17.6%); medium alkaline soil (from 7.6 to 8.0), area of which occupies 10.4 hectares (1.8%). The most acidic soils are in Districts of Polissya, in particular: 81.3% of all types of soils in Volodymyrets, 80.5% in Rokytne, 77.7% in Dubrovysya, 75.1% in Sarny, 70.0% in Berezne and 69.9% in Zarichne Districts. Indeed, the vast majority of sod-podzolic soils which are characterized by increased acidity are in these Districts. In Forest-Steppe zone the most acid soils observed in Districts: Korets (30.1%), Goshcha (25.3%) and Zdolbuniv (22.3%).

Nitrogen content

The nitrogen is in the form of both organic and mineral substances in several forms in the soil. Alkali-hydrolysed nitrogen plays the most

practical and important role in plant nutrition. Lands of Rivne region on the content of alkali-hydrolysed nitrogen can be divided into the following groups (Table 1): lands with very low content and with low content occupy 363.5 ha (63.8%) and 119.7 ha (21.0%) accordingly, lands with medium and high content occupy 39.6 ha (6.9%) and 47.3 ha (8.3%) accordingly.

The largest weighted average values of alkali-hydrolysed nitrogen are observed in Polissya Districts: Zarichne (145.4 mg/kg dry soil); Rokytno (121.7 mg/kg dry soil) and Sarny (118.7 mg/kg dry soil). This is due to the presence of large areas of peat and turf soils that have a high content of alkali-hydrolysed nitrogen in soils of these Districts. The lowest weighted average values of alkali-hydrolysed nitrogen are observed in Forest-Steppe zone, including: Rivne District (82.9 mg/kg dry soil), Mlyniv District (85.7 mg/kg dry soil), Goshcha District (87.5 mg/kg dry soil), Korets District (87.9 mg/kg dry soil) and Zdolbuniv District (88.7 mg/kg dry soil).

Phosphorus content

The total phosphorus content in soils is usually lower than that of nitrogen or potassium. Its content in different types of soils ranges from 0.04 to 0.22%, depending on soil texture and humus content (Melnychuk et al., 2004; Gorodny, 2008; Gorodny et al., 2005).

The poor in humus sod-podzolic soil is also characterized by a low content of phosphates. Phosphorus content decreases sharply with depth. Phosphorus in the form of mineral compounds dominates over the content of organic compounds. The mineral phosphorus compounds in the soil are in the form of calcium, iron and aluminum salts. Calcium phosphates dominate in the neutral and saline soils, iron and of aluminium phosphates dominate in acid soils (Melnychuk et al., 2004; Gorodny et al., 2005). The main minerals that present phosphorus in the soil are a fluorine-, chlorine- and hydroxyapatites. Phosphorus in an organic form is mainly in humus.

Phosphorus compounds in humus are about 50-70% of the total content of organophosphates in soil. The main part of the organic compounds of phosphorus is in the form of phytates, and phytates of iron and aluminium dominate in acidic soils, calcium phytate dominates in neutral soils (Melnychuk et al., 2004). Application of fertilizers is an important measure to improve the content of mobile phosphorus in the soil. In the dark grey forest soil and especially in chernozem, the mobility of the major mineral compounds of

phosphorus such as calcium phosphate is increased because of the slight soil acidification due to systematic applying of fertilizers.

Thus, phosphorus accumulated in these soils is more mobile and available to plants than the residual phosphorus of manure. Residual phosphorus of soluble phosphorus fertilizers includes quickly into physical, chemical and biological processes that occur in the soil (Melnychuk et al., 2004; Gorodny et al., 2005).

According to the Round IX (2006-2010) of Agroecological Monitoring on availability of mobile phosphates, soils of Rivne region can be divided into the following groups: soil with very low content of mobile phosphates (up to 26 mg/kg dry soil), area of soil occupies 45.2 thousand hectares (7.9% of total area); soil with low content (from 26 to 50 mg/kg dry soil), area of soil occupies 75.1 thousand hectares (13.2%); soil with medium content (from 51 to 100 mg/kg dry soil), area of soil occupies 144.7 thousand hectares (25.4%); soil with increased content (from 101 to 150 mg/kg dry soil), area of soil occupies 103.7 thousand hectares (18.2%); soil with high content (from 151 to 250 mg/kg dry soil), area of soil occupies 152.1 thousand hectares (26.7%); soil with very high content (more than 250 mg/kg dry soil), area of soil occupies 49.3 thousand hectares (8.7%).

The lowest weighted average values of mobile forms of phosphorus are observed in Polissya, particularly in following Districts: Zarichne (72.5 mg/kg dry soil), Berezhne (75.0 mg/kg dry soil), Sarny (79.0 mg/kg dry soil) and Volodymyrets (79.8 mg/kg dry soil). The sod-podzolic soils, which are poor in mobile phosphorus due to natural fertility of soil, are dominated in the Polissya. In the Forest-Steppe zone the lowest weighted average values of mobile phosphorus are observed in such Districts as Ostrog (117.5 mg/kg dry soil) and Korets (120.5 mg/kg dry soil). In these Districts during 2006-2010 the smallest amounts of phosphate fertilizer were applied: 11.0 kg/ha in Ostrog and 8.8 kg/ha in Korets (Table 2).

The highest weighted average values of mobile forms of phosphorus are observed in Districts of the Forest-Steppe zone, particularly in the Demydivka District (174.8 mg/kg dry soil), Zdolbuniv District (179.6 mg/kg dry soil), Mlyniv District (190.8 mg/kg dry soil) and Rivne District (174.4 mg/kg of soil).

Content of potassium

The content of potassium in soils is determined by soil forming rocks and minerals,

granulometric composition of soil, environmental conditions of Zone and peculiarities of land use. Potassium in soils is divided into the following forms: 1) water-soluble; 2) exchangeable; 3) hard exchangeable, or reserve; 4) non-exchangeable, including fixed potassium; 5) insoluble aluminosilicates potassium; 6) potassium of organic part of the soil. The content of water-soluble potassium in soils is very small, and its concentration depends on the degree of soil saturation by potassium and on the total concentration of salts in the soil solution. Equilibrium exists between water-soluble and exchangeable potassium: when potassium has been consumed by plants, the amount of its exchangeable forms has been decreased. The content of exchangeable potassium is used to assess the degree of potassium availability in the soil (Melnychuk et al., 2004; Gorodny, 2008; Gorodny et al., 2005). In Polissya soils which are pure in mobil potassium are dominated.

Chemical properties of potassium are similar to properties of cesium, and therefore potassium performs phyto-radioscopic function in agriculture in the conditions of radioactive contamination. With a lack of potassium in the nutrient medium, plant resistance to water and temperature changes is reduced as well as product quality; overall immunity of the organism to plant pathogenic effects is decreased (Melnychuk et al., 2004; Nosko et al., 1994).

Availability of soil by exchangeable potassium in the Region, according to the Round IX of Agroecological Monitoring, is characterized as follows: 1) very low content of exchangeable potassium (up to 41 mg/kg dry soil); there are 181.2 thousand hectares (31.8%) of soils with such properties; 2) low content (from 41 to 80 mg/kg dry soil); area of such soil occupies 211.0 thousand hectares (37.0%); 3) medium (81 to 120 mg/kg dry soil); area of soil occupies 110.1 thousand hectares (19.3%); 4) increased (from 121 to 170 mg/kg dry soil); area of soil occupies 47.2 thousand hectares (8.3%); 5) high (from 171 to 250 mg/kg dry soil); area of soil occupies 17.9 thousand hectares (3.1%); 6) very high (more than 250 mg/kg dry soil); area of soil occupies 2.7 thousand hectares (0.5%). The lowest weighted average values of exchangeable potassium content are observed in Polissya Districts: Volodymyrets (42.3 mg/kg dry soil), Dubrovytsya (46.3 mg/kg dry soil), Sarny (47.0 mg/kg dry soil) and Berezne (47.0 mg/kg dry soil). In these Districts sod-podzolic soils which are poor in content of

exchangeable potassium are dominated in the structure of the soil cover.

The highest weighted average values of exchangeable potassium content are observed in Districts of the Forest-Steppe zone, including: Mlyniv (103.9 mg/kg dry soil), Zdolbuniv (100.1 mg/kg dry soil), Demydivka (92.4 mg/kg dry soil) and Rivne (90.9 mg/kg dry soil).

The humus content

Soil fertility depends on many soil's properties, but mainly is determined by the finite number of key indicators, among the most important are the content and reserves of humus. Humus is the main factor that determines all the properties of the soil. It is the most important source of soil nutrition elements. In its structure humus contains all the basic elements of plants and microorganisms nutrition (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and microelements). With the gradual mineralization of humus these elements pass into mineral forms and are used by plants. During decomposition of humus and organic residuals, a large amount of carbon dioxide (CO₂) needed for photosynthesis of green plants is evolved (Melnychuk et al., 2004; Gorodny, 2008; Gorodny et al., 2005).

According to results of Round IX of Agroecological Monitoring (2006-2010), the areas of soils with different supply of humus in Rivne region can be divided into the following groups: the first group (content of humus is less than 1.1%); area of the first group soil occupies 7.9 thousand hectares (1.8%); the second group (content of humus is 1.1-2.0%); area of soil occupies 192.0 thousand hectares (43.8%); the third group (content of humus is 2.1-3.0%); area of soil occupies 183.3 thousand hectares (41.8%); the fourth group (content of humus is 3.1-4.0%), area of soil occupies 49.4 thousand hectares (11.3%); the fifth group (content of humus is 4.1-5.0%), area of soil occupies 4.5 thousand hectares (1.0%); the sixth group (content of humus is over than 5.1%), area of soil occupies 1.4 thousand hectares (0.3%).

The lowest weighted average values of humus content are observed in Polissya Districts: Berezne (1.85%), Volodymyrets (1.90%), Rokytne and Kostopil (1.95% each). In these Districts sod-podzolic soils dominated in the structure of the soil cover. These soils are poor in organic matter content; humus content in organogenic soils was not determined. The highest weighted average values of humus were observed in Districts of the

Forest-Steppe zone, including: Radyvyliv (2.73%), Ostrog (2.57%) and Goshcha (2.28%). In these areas dominated soils that are richer in humus than soils of Polissya.

The content of microelements

Microelements enhance normal rate of physiological and biological processes in plants, affect the process of chlorophyll synthesis, increasing the rate of photosynthesis. Under the influence of microelements plant resistance against diseases and various unfavourable environmental conditions as lack of moisture in the soil and decreasing or increasing of the temperature has been increased.

In Round IX of Agroecological Monitoring (2006-2010), areas of soils containing boron can be divided into the following groups: with low content of boron (56.8 thousand hectares), with medium content (280.3 thousand hectares), with high content (195.4 thousand ha). The weighted average value of boron content for the period of Round IX of Agroecological Monitoring in Rivne region is 0.57 mg/kg dry soil. Comparing between Districts, weighted average values of boron content in the soil is not different significantly; all Districts have average content value that ranges from 0.52 to 0.61 mg/kg dry soil.

On the content of magnesium, areas of soil of Round IX of Agroecological Monitoring can be divided into the following groups: low content of magnesium in the soil, area of soil occupied 96.4 thousand hectares; medium content, area of soil occupied 149.1 thousand hectares; high content, area of soil occupied 287.0 thousand ha. Weighted average value of magnesium content in the Region is 56.9 mg/kg dry soil. In different Districts weighted average values of magnesium content range from 35.2 to 70.5 mg/kg dry soil. The lowest weighted average values of magnesium content are observed in Districts of Polissya, including: Zarichne (35.2 mg/kg dry soil), Rokytne (43.0 mg/kg dry soil), Dubrovysya (44.9 mg/kg dry soil), Berezne (46.0 mg/kg dry soil) and Kostopil (46.2 mg/kg dry soil). The highest weighted average values of magnesium content are observed in Districts of the Forest-Steppe zone: Radyvyliv (70.5 mg/kg dry soil), Goshcha

and Korets (69.0 mg/kg dry soil each) and Demydivka (66.4 mg/kg dry soil).

Farmlands of Rivne region on the content of copper can be divided into the following groups: with low content of copper in soil (167.4 thousand hectares), with average content (129.7 thousand hectares), with high content (235.1 thousand hectares). Weighted average value of copper content in the Region is 2.2 mg/kg dry soil.

Districts of Polissya in general have lower weighted average values of copper content and larger areas of soil with low copper content, particularly in Rokytne and Zarichne Districts (1.1 mg/kg dry soil each), Dubrovysya and Volodymyrets Districts (1.3 mg/kg dry soil each). The vast majority of soils in these Districts are soils with light granulometric structure, which are poor in copper content. The highest values of copper content among Districts of Forest-Steppe zone are in: Dubno (2.8 mg/kg dry soil), Zdolbuniv and Rivne (3.3 mg/kg dry soil each), Mlyniv and Demydivka (3.4 mg/kg dry soil each). In these Districts a significant part of the soils, which are characterized by higher copper content are podzolic black soils, typical black soils, dark grey and grey podzolic soils.

On the content of zinc, soils of Rivne region can be divided into the following groups: with low content of zinc (area of soil is 132.3 thousand hectares), with medium content (area of soil is 13.1 thousand hectares), with high content (area of soil is 132.3 thousand hectares). Weighted average value of zinc content in the Round IX of Agroecological Monitoring is 1.7 mg/kg dry soil. On the content of cobalt soils of Rivne region can be divided into the following groups: with low content of cobalt in soil (area of soil is 0.7 thousand hectares), with medium content (area of soil is 7.1 thousand hectares), with high content (area of soil is 126.5 thousand hectares). The weighted average value of cobalt content in the soils of the Region is 2.9 mg/kg dry soil. In the Round IX of Agroecological Monitoring analysis on the cobalt content were performed only in five Districts of Forest-Steppe zone on a total area of 134.3 thousand hectares.

Table 1. Characteristics of investigated lands on the content of alkali-hydrolysed nitrogen, mg/kg dry soil.

District	Round of Monitoring	Year of Investigation	Area of Investigation, thousand ha	Distribution of soil's areas on the content of alkali-hydrolysed nitrogen								Weighted average values, mg/kg of dry soil
				very low		low		medium		high		
				<101 mg/kg dry soil		101-150 mg/kg dry soil		151-200 mg/kg dry soil		200 mg/kg dry soil		
				100 0 ha	%	1000 ha	%	1000 ha	%	1000 ha	%	
Berezhne	VIII	2004	37.3	20.5	55.0	9.4	25.2	3.4	9.1	4.0	10.7	110.5
Berezhne	IX	2009	43.2	25.4	58.8	10.7	24.8	3.0	6.9	4.1	9.5	106.8
Volodymyrets	VIII	2005	58.0	25.9	44.7	11.7	20.2	5.6	9.7	14.8	25.5	127.9
Volodymyrets	IX	2010	37.3	22.7	60.9	4.7	12.6	4.2	11.3	5.7	15.3	112.4
Goshcha	VIII	2001	34.8	28.2	81.0	5.1	14.7	0.8	2.3	0.7	2.0	87.4
Goshcha	IX	2006	26.7	21.1	79.0	4.5	16.9	0.9	3.4	0.2	0.7	87.5
Demydivka	VIII	2002	11.7	9.0	76.9	2.7	23.1	0.0	0.0	0.0	0.0	86.6
Demydivka	IX	2007	15.0	11.1	74.0	3.5	23.3	0.3	2.0	0.1	0.7	89.6
Dubno	VIII	2003	47.2	32.2	68.2	9.2	19.5	1.5	3.2	4.3	9.1	99.7
Dubno	IX	2008	56.9	35.3	62.0	12.0	21.1	2.5	4.4	7.1	12.5	106.4
Dubrovysya	VIII	2005	45.3	13.4	29.6	11.4	25.2	8.1	17.9	12.4	27.4	141.2
Dubrovysya	IX	2010	24.7	13.5	54.7	5.5	22.3	2.8	11.3	2.9	11.7	112.8
Zarichne	VIII	2005	34.9	6.9	19.8	6.0	17.2	4.9	14.0	17.1	49.0	161.2
Zarichne	IX	2010	27.3	7.5	27.5	6.4	23.4	4.4	16.1	9.0	33.0	145.4
Zdolbuniv	VIII	2002	20.6	16.2	78.6	4.1	19.9	0.1	0.5	0.2	1.0	86.4
Zdolbuniv	IX	2007	21.5	16.3	75.8	4.6	21.4	0.3	1.4	0.3	1.4	88.7
Korets	VIII	2001	22.4	19.1	85.3	2.6	11.6	0.3	1.3	0.4	1.8	84.5
Korets	IX	2006	33.4	26.0	77.8	6.2	18.6	0.8	2.4	0.4	1.2	87.9
Kostopil	VIII	2006	17.8	12.4	69.7	3.8	21.3	0.6	3.4	1.0	5.6	96.4
Kostopil	IX	2010	30.4	17.8	58.6	9.4	30.9	2.3	7.6	0.9	3.0	101.9
Mlyniv	VIII	2003	46.9	39.9	85.1	6.9	14.7	0.1	0.2	0.0	0.0	82.9
Mlyniv	IX	2008	58.5	49.1	83.9	7.0	12.0	1.2	2.1	1.2	2.1	85.7
Ostrog	VIII	2001	20.9	14.4	68.9	5.5	26.3	0.7	3.3	0.3	1.4	93.7
Ostrog	IX	2006	29.5	14.4	48.8	10.9	36.9	1.3	4.4	2.9	9.8	110.7
Radyvyliv	VIII	2002	39.1	31.9	81.6	7.2	18.4	0.0	0.0	0.0	0.0	84.3
Radyvyliv	IX	2007	44.3	26.7	60.3	13.7	30.9	3.0	6.8	0.9	2.0	99.9
Rivne	VIII	2002	46.1	42.7	92.6	1.8	3.9	0.7	1.5	0.9	2.0	80.8
Rivne	IX	2007	44.8	39.7	88.6	3.5	7.8	0.8	1.8	0.8	1.8	82.9
Rokytno	VIII	2004	26.2	12.9	49.2	5.1	19.5	3.8	14.5	4.4	16.8	125.1
Rokytno	IX	2009	25.6	12.1	47.3	4.8	18.8	5.7	22.3	3.0	11.7	121.7
Sarny	VIII	2004	54.9	19.0	34.6	14.5	26.4	9.2	16.8	12.2	22.2	134.0
Sarny	IX	2009	51.0	24.8	48.6	12.3	24.1	6.1	12.0	7.8	15.3	118.7
Total for Region	VIII	2001-2005	564,1	344,6	61,1	107,0	19,0	39,8	7,1	72,7	12,9	108,4
	IX	2006-2010	570,1	363,5	63,8	119,7	21,0	39,6	6,9	47,3	8,3	103,1

Conclusions

Results of IX Round of Monitoring of the agricultural lands in Rivne region (2006-2010) showed that the stabilizing process of the content of essential nutrients, phosphorus and potassium began in the soil. Compared with VIII Round of Monitoring (2001-2005), the weighted average content of mobile phosphorus in the region increased by 19 mg/kg of dry soil, and the content of exchangeable potassium increased by 9 mg/kg of dry soil.

The highest increasing of mobile phosphorus and exchangeable potassium contents was observed in soils of Forest-Steppe Districts with intensive farming. Stabilization of the main nutrients in the soils of farmlands of Forest-Steppe zone can be explained by use of the minimization of tillage, increased use of fertilizer, use tools of agriculture biologization as primarily plowing of straw, stalks and other crop residues and green manures.

Table 2. Application of mineral fertilizers on crops by agrarian farms of Rivne region during Round VIII (2001-2005) and Round IX (2006-2010) of Agroecological Monitoring, kg/ha of crop.

District	Application of mineral fertilizers, kg/ha of crop							
	2001-2005				2006-2010			
	total NPK, kg/ha	including			total NPK, kg/ha	including		
		nitrogen	phosphorus	potassium		nitrogen	phosphorus	potassium
Polissya								
Bereziv	11.0	8.0	1.0	2.0	9.8	7.2	1.3	1.3
Volodymyrets	15.6	11.9	1.8	1.9	7.8	4.9	1.6	1.4
Dubrovysya	18.3	15.6	1.4	1.2	15.5	10.0	2.5	3.0
Zarichne	2.9	2.6	0.1	0.2	3.1	2.6	0.3	0.3
Kostopil	16.8	12.5	1.4	2.9	14.9	11.8	1.2	2.0
Rokytnе	9.5	8.0	0.8	0.7	9.0	6.7	1.1	1.3
Sarny	18.8	12.0	2.7	4.0	28.8	16.9	4.7	7.2
Total in Zone	15.0	11.0	2.0	2.0	15.0	10.0	2.0	3.0
Forest-Steppe zone								
Goshcha	88.2	46.2	16.7	25.3	169.8	89.7	25.5	54.6
Demydivka	22.5	17.0	2.2	3.3	60.8	40.2	7.7	12.9
Dubno	49.0	37.1	4.2	7.7	110.3	71.8	16.6	21.9
Zdolbuniv	48.7	38.4	3.6	6.7	90.6	59.7	12.4	18.4
Korets	36.7	27.8	4.6	4.3	84.3	49.1	8.8	26.4
Mlyniv	72.8	44.9	9.0	18.9	173.6	96.4	22.6	54.6
Ostrog	27.4	22.0	2.6	2.7	55.8	30.8	11.0	14.0
Radyvyliv	69.8	51.1	5.1	13.6	131.2	86.9	13.7	30.7
Rivne	53.6	42.0	4.8	6.7	116.4	65.9	19.6	30.9
Total in Zone	56.0	39.0	6.0	11.0	121.0	71.0	17.0	33.0
Total in the Region	43.0	30.0	5.0	8.0	97.0	57.0	14.0	26.0

At the same time there is a tendency to reduce these rates in soils belonging to Polissya part of the Region. Decreased content of mobile phosphorus and exchangeable potassium in soils of Polissya is associated with a decrease in the use of organic and mineral fertilizers in farms.

Dominated soils of Polissya lands have a light granulometric composition (sandy and sandy-loam soils) that have very low and low nitrogen content (90-113 mg/kg dry soil).

Round IX of Agroecological Monitoring of farmlands of Rivne region showed that the weighted average value of soil humus content is not changed, but in Districts that belongs to Polissya zone the value of soil humus content have a tendency to decrease. The present value of humus in farmlands of Rivne region is 2.15%.

The negative dynamics of soil acidity was shown, and areas with high acidity soils are increasing. Nowadays they occupied 39.3% of farmlands of Rivne region.

As a result in Round IX of Agroecological

Monitoring Research (2006-2010) the region has 56.8 thousand ha of farmlands with soils which are low in boron, 167.4 thousand hectares with soils which are low in copper, 96.4 thousand hectares with soils which are low in magnesium and 132.3 thousand hectares with soils which are low in zinc. All of these areas require urgent application of relevant microelements. Sharply reduced availability of soil microelements in soils can be explained by the reduction of using of organic and mineral fertilizers on the territory of Rivne region, especially in Polissya.

For a non-deficit humus balance, stabilization of the content of main nutrients and microelements, agriculture of Rivne region, especially in Polissya, needs to increase the application of organic fertilizers by increasing of the manure production, production of peat-manure composts, sapropel extraction, and application of green manure crops. Also it is necessary to increase the application of organic fertilizers of new generation, to expand the area under

perennial legumes and put more emphasis on plowing of crop residues.

Author contributions

L. M. evaluated the experimental data, provided Agroecological assessment of soil and corrected the article. I. Y. planned and designed the Monitoring study of soil, collected the data. M. D. analyzed and interpreted the experimental data, searched literature, wrote the article.

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