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Methodological features of calculations of doses of fertilizers in crop rotations on drained organogenic soils

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The purpose. To determine efficiency of methods of calculation of doses of fertilizers and features of formation of optimum nutritive regimen of drained organogenic soils using scientifically justified norms of importation of fertilizers depending on techniques which consider characteristics of these soils and cultivated crops. **Methods.** Field with complex of biometric, agrochemical and laboratory researches, mathematical-statistical. **Results.** Formation of nutritive regimen of soil and productivity of crops in crop rotation on drained organogenic soils depending on methods of calculation of doses of fertilizers is considered. Agrochemical and economic assessment is made, the priority methods which can be used in production on drained organogenic soils are certained. **Conclusions.** Analysis and assessment of calculation of importation of fertilizers on increase of yield and planned productivity in view of the content of nutrients in soil have shown that use of existing methods of calculation of doses of fertilizers in system of exact farming agriculture on drained organogenic soils causes application of overestimated doses of fertilizers. The greatest productivity of long-term grass mixtures of the first and second years of growing (8,2 and 9,4 t/hectare of dry mass), winter rye (5,25 t/1 hectare) and corn for grain (8,39 t/hectare) was gained at importation of doses of the fertilizers gained on the basis of data of the analysis of long researches. Such doses of fertilizers ensured the greatest increase of yield per unit of fertilizer. Economic assessment of doses of the fertilizers calculated by various methods has shown that the lowest cost price of the gained yield and the greatest conditional-net profit, as well as the level of profitableness of cultivated crops, was in sowings with importation of fertilizers calculated on the basis of the analysis of data, gained in long researches.

Key words: *fertilizers, methods of calculation, drained melioration, exact farming agriculture, formation of crop.*

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The introduction of precision agriculture in Ukraine, developed in 90-90s of the twentieth century. It is a logical continuation of the epoch programming of harvests [1-3]. Acquired knowledge allow to use the newest approaches of differentiated direction specifically on solving the main problems on different types of soils, especially on the meliorated organogenic, clarification of methodology of calculation of optimum nutrient regime of soil taking into account Not only modern technical measures, but also the general economic indicators [4-7].

Presence in peat-swamp soils significant amount of nitrogen and their ability to provide plants during the vegetation moisture, contribute to the intense growth and development of crops. These features of organogenic soils together with agricultural crops cultivation significantly affect the nourishing regime of the soil [8-12].

The main methods of determining the norms of mineral fertilizers by many scientists [2, 13, 14] accepted: Calculations on the basis of data analysis of perennial field studies and Balansovo-settlement methods. The latter have a number of methods: doses are designed to increase yield, the planned yield, taking into account the content of nutrients in the soil, coefficients of the use of nutrients from soil elements and fertilizers, weeded crops, the removal of a side of nutrients, the mineralization of peat, etc. [11, 15].

The above indicates the importance of defining the basic principles of methodology for forming optimum nutrient regime of drained organogenic soil.

Purpose of the work: Defining the principles of optimum nutritious mode of degenerated organogenic soils by establishing scientific-reasonable norms of mineral fertilizers application, depending on the techniques, taking into account characteristics of these Soils and cultivated crops.

Methodology of researches. Researches were carried out in a stationary experiment in an octagonal grain-feed crop rotation on the drained degenerated old-, organogenic soils of pan-industrial Research Station NSC "Institute of Agriculture of NAAS" (Floodplain r.Supiy of Yagotin District of Kyiv region). Soil of the research site – carbonate rogozovo-osomal origin peat with a high degree of decomposition – 45-55% and capacity of peat layer

2.4-2.5 m; the density of the soil is 0.215 g/cm3, 270-285% full moisture capacity, ash-40%. Gross content of nitrogen is 2.93%; phosphorus – 0,76-0,90%; potassium – 0,09-0, 15%; calcium – 20-26%; Ph of aqueous solution – 7.3-7.5. Underlying maternal breed – gleyed alluvial loam.

The experiment is laid down in three-digit repetition, both in space and in time, according to the scheme the following in table 1. To determine the effectiveness of fertilizers and the comparison of calculations in the scheme the experiment added areas: "No fertilizer" and "no fertilizer + organic balance". Recommended doses of fertilizers were obtained on the basis of analysis of data of perennial researches in crop rotation on the degenerated organogenic rubber conducted by NSC «Institute of Agriculture of NAAS» with receipt of the largest harvests. The total area of the plot is 20 m^2, accounting is 15 m^2.

1. Scheme of research

№ opt-ion	Culture	The recommended dose of fertilizer is calculated based on data analysis of perennial researches	Calculated dose on yield increase	Designed for planned yield taking into account the nutrient content in the soil	Recommended dose + stimulator of growing
1	Perennial grasses 1-5 year	$N_{45}P_{45}K_{60+60}$	$N_{45}P_{84}K_{90+85}$	$N_{45}P_{138}K_{120+120+53}$	$N_{45}P_{45}K_{60+60}$ + стимулятор росту
2	Perennial grasses 6 year + rye winter	$N_{45}P_{45}K_{60+60}$	$N_{45}P_{84}K_{90+60}$	$N_{45}P_{138}K_{173+120}$	$N_{45}P_{45}K_{60+60}$ + стимулятор росту
3	Rye winter	$R_{45}K_{120}$	$R_{115}K_{55}$	$P_{100 + 166}K_{127}$	$R_{45}K_{120}$ (Spring) + stimulator of growth
4	Corn for grain + perennial grasses	$R_{45}K_{120}$	$R_{200}K_{164}$	$R_{323}K_{267}$	$R_{45}K_{120}$ (Spring) + stimulator of growth

Organic-balance is a biological product for stimulation of growth and development and provision of balanced nutrition of plants on the basis of concentrated suspension cultures of living nitrogen-fixing, phosphorus and potassium-mobilizing, as well as the sparing fungicidal effect of microorganisms and products of their life: vitamins, enzymes, amino acids, natural antimicrobial substances.

In soil samples humidity determined by thermostatic-weight method, content of nitrate nitrogen – for Granwald-lyazjy with disulfphenoil acid according DSTU 4725-2007, content of ammonium nitrogen – by extraction of potassium chloride solution according to DSTU ISO/TS 14256-1:2003; the content of moving compounds of phosphorus and potassium is a method of secondary photometry of the carbonic hood for B. T. Machihin according to DSTU 4114-2002. Yield accounting was performed during the ripeness of cultures by the separative method [13].

Weather conditions during studies in the area of research areas were characterized by elevated average monthly indicators, the air temperature, which for April-September was 17.4-18.1°C (norm -15.5°C) and fewer of the norm (327 mm) pprecipitations: 2016 – 319 mm, 2017 – 163.2 and 2018 – 224 mm.

Calculation of the doses of fertilizers on the planned yield increase was carried out according to the formula (1.1), and for NPK of the planned harvest, minus their content in the soil – by the formula 1.2 [2, 6]:

$$D = (У_3 - У_к) \times В \times 100 / К_у \qquad (1.1);$$

$$D = У_з \times B - P\ К_п \times 100 / К_у, \quad (1.2);$$

Where: D – the dose of fertilizers, kg per 1 hectare of active substance;

$У_з$ – planned harvest, t/ha;

$У_к$ – perennial yield without fertilizers, t/ha;

B – nutrient removal by plant, kg/t;

P – soil nutrient supply, kg/hectare;

$К_у$ – fertilizer utilization ratio,%;

$К_п$ – utilization rate of soil nutrients, %.

The coefficients of the use of nutrients from the soil and fertilizers were calculated based on the perennial data obtained on these soils. Mathematical processing of the obtained results of field researches was carried out by the method of dispersing analysis [13, 14]:

Research results. Analysis of nutrient content in the soil shows (table 2), that it essentially depends not only on doses of fertilizer, but is quite different in different cultures. The smallest of their number is marked on unfertilized areas and under the sowing of perennial grass mixtures. As for individual elements, the smallest fluctuation from various influencing factors, had the content of mobile phosphorus, fluctuations did not exceed 39.1 mg per 1 kg of dry soil. Whereas for nitrate nitrogen this indicator was 278.5 mg and potassium – 71.5 mg per 1 kg of dry soil. In our opinion, this is associated with the presence of layers of vivianitis with a significant content of phosphorus compounds. In the process of meliorative tillage, vivianite layers are faced with air and the nitty compounds of phosphorus pass into oxides and its moving forms, which neutralize the level of the content of moving forms of phosphorus by variants [8].

The soil had moving nitrogen forms with high security under all the crops and irrespective of the incurred fertilizers. Its largest performance (280-338 mg per 1 kg of dry soil) were under the sowing of corn, where during the growing season was held a row tillage, which contributed to the intensive mineralization of peat and the accumulation of movable forms of nitrogen [2].

The content of moving potassium in the soil completely depended on the mineral fertilizers. The largest content was in the areas of calculation of its introduction to the planned yield taking into account the content of nutrients in the soil and on the growth of the harvest and provided the largest content of the moving forms of potassium on the non-replaceable crops of perennial grasses-153-179 mg Kg mixtures of the first year of cultivation – 201-204 mg/kg; winter rye – 159-163 and maize for grain – 148-154 mg per kg of dry soil against control (without fertilizer), respectively: 127; 181; 134 and 131 mg per 1 kg).

However, it is important that regardless of the methods of calculating nutrients in the soil, annuals and perennial crops in the crop rotation had high provision of nutrients [12, 15]. Such provision of soil nutrients respectively influenced and the yield of crops (table. 3).

2. Influence of mineral fertilization on nutrient content in soil layer 0-30 cm, average for vegetation 2016-2018, mg per 1 kg of dry soil

Calculations of fertilizer	N-NH_4	N-NO_3	P_2O_5	K_2O
Non-variable cultivation of perennial grasses				
Without fertilizer (control)	26	59	68	127
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	35	99	78	144
Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	28	146	88	154
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	21	106	90	179
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha	22	81	87	155
Stimulator of growth – Organic balance – 2 L/ha	26	73	68	133
Perennial herb of the first year of cultivation				
Without fertilizer (control)	26	144	71	181
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	24	188	78	196

Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	20	156	78	204
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	22	181	77	201
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha	23	177	75	194
Stimulator of growth – Organic balance – 2 L/ha	23	155	72	180
Rye winter				
Without fertilizer (control)	23	160	58	134
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	22	161	65	189
Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	20	177	75	163
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	20	155	64	159
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha	17	155	61	135
Stimulator of growth – Organic balance – 2 L/ha	22	149	56	129
Corn for grain				
Without fertilizer (control)	16	179	52	131
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	13	237	60	146
Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	13	280	67	148
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	13	338	63	154
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha	12	282	55	146
Stimulator of growth – Organic balance – 2 L/ha	14	257	51	110
SSD_{05}	1,6	17,6	2,1	15,1

In general, it can be noted that the fluctuations in yield of crops, depending on options for calculating fertilization, under the study of annuals and perennial culture was different and did not exceed 9.2-9.4%. Thus, yields of green mass of perennial

3. Productivity of crops in crop rotation, average 2016-2018 years, T on 1 ha

Fertilizer option	Non-variable cultivation of perennial grasses	Perennial herb of the		Rye winter	Corn for grain
		second year of cultivation	first year of cultivation		
Without fertilizer (control)	5,9	6,5	6,3	3,95	5,74
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	9,9	8,8	8,1	5,23	7,69
Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	9,2	8,5	7,7	4,89	7,39
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	9,8	8,3	8,1	4,81	7,31
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha	9,2	9,4	8,2	5,25	8,39
Stimulator of growth – Organic balance – 2 L/ha	8,6	7,2	6,9	4,01	6,29
SSD_{05}	0,23	0,28	0,25	0,21	0,23

mixtures of the second year of cultivation in the variants of fertilization, designed for on the basis of data analysis obtained in years, calculated on the increase in yields and designed for all yields from Taking into account their content in the soil ranged within 8.3-8.8 t per 1 hectare of dry mass, grain of rye winter, respectively – 4,81-5.23 and corn grain – 7.31-7.63 t/ ha 1 hectare. That is, a little more than the smallest significant difference. At the same time, the amount of mineral fertilizers, depending on the options for calculating their entry into the soil, has a big difference, which, of course, influenced the production costs and in general-on the cost of the grown products.

The economic assessment of the introduction of doses of fertilizers designed for different methods in crop rotation on organogenic soils, the Humidic zone shows (table 4), that the value of the grown crop is little different in variants with various calculations of fertilizers, the average culture is not is greater than 4.0-8.2%, at the same time, production costs are already different in 1.85-2.2 times.

Significant production costs for the cultivation of crops associated with the high cost of mineral fertilizers. Therefore, crops growing crops with the deposition of high doses of fertilizers are high cost, and conditionally net profit and the level of profitability of growing crops are significantly reduced. Thus, the obtained data on the effective use of destored organogenic soils, taking into account the application of mineral fertilizers, designed for different methods for agricultural crops show that the economically most advantageous and scientifically Justified is the introduction of mineral fertilizers obtained on the basis of perennial scientific data, taking into account soil-climatic and weather conditions.

4. Economic evaluation of fertilizers designed for by different methods in crop rotation on the drier organogenic soils, the average of 2016-2018 years

Fertilizer option	Yield, t/ha	Cost of harvest, UAH/ha	Production costs, UAH/ha	Cos
Perennial herb of the secondary year of cultivation				
Without fertilizer (control)	6,5	21420	3554	
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	8,8	31620	12267	
Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	8,5	30608	14743	
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	8,3	29580	22763	
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha)	9,40	33660	13148	
Stimulator of growth – Organic balance – 2 L/ha	7,20	23970	4446	
Rye Winter				
Without fertilizer (control)	3,95	19355	6759	
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	5,23	25627	13960	
Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	4,89	23961	13297	
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	4,8	23520	21443	
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha	5,3	25970	14600	
Stimulator of growth – Organic balance – 2 L/ha	4,0	19600	7437	
Corn for Grain				
Without fertilizer (control)	5,7	25650	6119	
Recommended dosage of experiences-based fertilizers ($N_{45,45}K_{60+60}$)	7,6	34200	13257	
Estimated dose on yield increase ($N_{45,84}K_{90+60}$)	7,4	33300	20293	
Estimated on the planned yield taking into account the nutrient content in the soil ($N_{45,138}k_{173+120}$)	7,3	32850	28877	
Recommended Dose ($N_{45}P_{45}$ K_{60+60}) + Organic-Balance 2 L/ha	8,4	37800	14030	
Stimulator of growth – Organic balance – 2 L/ha	6,3	28350	6775	

Conclusions

Analysis and estimation of the mineral fertilizers for the yield increase and the planned yield taking into account the nutrient content in the soil showed that the use of existing methods of calculation of doses of fertilizers in the system of precision agriculture on the organogenic soils leads to the application of inflated doses of mineral fertilizers.

The highest yield of perennial grass mixtures of the first and second years of cultivation (8.2 and 9.4 t per hectare of dry mass), winter rye (5.25 t for 1 hectare) and corn for grain (8.39 t per 1 hectare) received for the introduction of doses of fertilizers obtained based on the analysis of data long Research. Such doses of fertilizer provided the largest increase in harvest per unit of fertilizer.

Economic assessment of the determination of doses of fertilizers, designed for different methods showed that the lowest cost of the yield and the largest conditional net profit, as the level of profitability of farmed crops, had to crops with the introduction of fertilizers, designed for based on the analysis of data obtained in long-term investigations.

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