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Cycle of nitrogen in different crop rotations of Left-bank Forest-steppe

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The purpose. To determine normative parameters of typification of nitrogen balance (N) in agrocoenosis of different crop rotations, as a component of methodology of agro-ecological assessment of their productivity at use of collateral products as organic fertilizers in conditions of state-of-the-art climatic system of Forest-steppe of Ukraine. **Methods.** Generalization of results of long-term researches in field stationary experience, statistical: dispersing, correlative, factor, cluster analyses of parameters and quantitative points of nitrogen balance. **Results.** In 7 and 10-field crop rotations the typical interval of change of capacity of balance is 456 – 621 kg/hectare, and receipt of nitrogen in agrocoenosis of crop rotations correlates (R=+0,82±0,03) with removal of nitrogen with basic products. Capacity of balance at the level of direct strong correlation is linked to increase of productivity of crop rotations. The maximum productivity of crop rotations as to exit of feed and forage-protein units is attained at capacity of balance more than 580 kg/hectare. In 3 – 5-field crop rotations nitrogen balance was positive, and capacity of balance at the maximum productivity as to exit of feed and grain-protein units made 590 – 705 kg/hectare that is linked to absence of perennial grasses. **Conclusions.** In crop rotations with long rotation the ratio of removal of nitrogen to receipt is declined in favor of removal, whereas in 3 – 5-field crop rotations, on the contrary, in favor of receipt of nitrogen.

Key words: *nitrogen, capacity of balance, intensity of balance, crop rotations, normative parameters of balance.*

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The problem of nitrogen is one of the most important in agro-geology, agrochemistry and agriculture, and the availability of nitrogen in agricultural crops in agrocenoses of uneven crop rotation is one of the determining factors in the formation of their productivity and reproduction of chernozem fertility. It is important to comprehensively examine the direction and degree of changes in nitrogen circulation under the influence of long-term application of uneven crop rotation [1] to control the processes of crop nutrition, the formation of high and high yield crops, and the regulation of soil fertility under intensive agriculture.

The turn of nitrogen - is the main biogeochemical cycle that occurs in agroecosystems [2]. The deficiency of mineral and organic forms of soil nitrogen negatively affects the development of agrophytocenoses, influencing the depositing of carbon in the atmosphere, which exacerbates the effects of global climate change [3-4]. Generally, the inclusion of the nitrogen cycle of agroecosystems into climatic models as an integral characteristic of the carbon cycle [5], and the exclusion of the nitrogen cycle in the consideration of the effects of climate change leads to an inadequate assessment of the agroecosystem response, where the mineral forms of soil nitrogen is a limiting factor for the development of terrestrial vegetation, as in natural coenoses [6-7], and in agrocenoses [8-9].

The development of the methodology of agroecological assessment of the productivity of uneven grains and crop rotation on the basis of establishing normative parameters of nitrogen circulation models with the use of by-products as organic fertilizers in the conditions of the modern climatic system of the forest-steppe of Ukraine is still relevant.

The purpose of research. Set normative parameters of typing nitrogen balance in agrocenoses of diversified crop rotation, as a component of the methodology of agroecological assessment of their productivity with the use of by-products as organic fertilizers under the conditions of the forest-steppe of Ukraine.

Research methods. Generalization of results of long-term research in field stationary research, static: dispersion, correlation analysis of productivity parameters, phytomass structure and quantitative articles of nitrogen balance.

The method of conducting research. The research was carried out in the central part of the left-bank forest-steppe of Ukraine in the long-term (more than 50 years) stationary experiment of the Drabiv experimental field of the Cherkasy State Agricultural Research Station "NSC" Institute of Agriculture of NAAS ". The experiment is located on chernozem with a typical low-humus large-pulverized light-gravel containing humus - 3,8-4,2%, the content of mobile phosphorus - 120-140 mg per 1000 g soil, moving potassium - 80-10 0 mg per 1000 g soil. pNH2O = 6.8-7.0. Fertilizer systems include the following fertilizer doses: winter wheat, corn, spring barley, wheat germ, soya N60P60K60, peas - N20P40K40, sunflower - N40P40K40, sugar beet - N100P100K100. From 2000 to 2016 - as an organic fertilizer, all by-products are used.

In a stationary experiment, there are nine - 10-type crop rotation; 12 five-breeding, two four-wheeled, one semipillar and three-trypillous crop rotations (Table 1).

Table. 1. Structure of crop rotation in the experiment

№	The structure of crop rotation in the experiment
18*	50% grain; 10% -above; 20% -think; 20% fodder: no fertilizer
5	50% -green; 20% -think; 30% fodder.
17	40% - cereals; 20% - beans; 30% -technical; 10% - fodder
12	40% - cereals; 10% sugar beets; 30% fodder; 10% -good
7	50% green; 10% -above; 30% - prosapny; 10% fodder
14	70% - grain; 10% - beans; 20% technical
9	50% -grains; 10% -above; 20% -think; 20% Fat: With fertilizers
8	50% grain, 30%; 20% fodder
2*	50% grains; 20% sugar beets; 20% big; 10% - fodder.
16**	56% -grains (28% -experienced wheat); 43% -technical; 14% - one year grass
13**	72% -grains; 14% sugar beets; 14% perennial grasses
4***	60% -grains (40% -years of spike); 20% rape; 20% -good
1	60% grains; 20% sugar beets; 20% - one-year grass
11	60% - grain (40% wheat isozym); 20% rape; 20% - one-year grass
11a	40% -grains; 40% sugar beets and soy beans; 20% -good
4a	60% -green (40% -years of the eartag); 20% sugar beet; 20% - peas
6	40% - cereals; 40% -technical (soy-20%; rape-20%); 20% -good
6a	40% grains; 20% big; 20% sugar beets; 20% - corn for silage
15	60% grains; 20% sugar beets; 20% - one-year grass.
1a	60% grains; 20% big; 20% sugar beets
10a	60% grains; 20% sugar beets; 20% - one-year grass
15a	60% grains; 20% sugar beet; 20% - one-year grass
10***	60% - cereals (40% corn); 20% - peas; 20% - fodder.
3	50% -green (25% corn); 25% - sugar beets; 25% - forage
13a#	66% -grains (33% - barley); 34% - soybeans
3a	66% -grains (33% - barley); 34% are peas
3б	66% -grains (33% - spring wheat); 34% - soybeans
16в#	66% corn; 34% - soybeans
Note: * No. 18-2 - 10 piles of crop rotation; ** No. 16,13 - 7th crop rotation; *** No. 4-10 - five crop rotations; № 3 - 4 free crop rotation; # №13a-16в - 3-crop crop rotation	

When calculating the balance N, the following items of arrival and expenditure are taken into account: B-N = (Nd + Nc + Nob) - (Nv + Npg + Npv) where B-N - nitrogen balance, Nd - fertilizer nitrogen, Nc - nitrogen introduced with seeds , Nob - amounts of soil enrichment with biological nitrogen, NB - removal of nitrogen by plants (main and by-products), Npg -gase-like losses of N, which make up from 15 to 25% of the dose made with nitrogen fertilizers, NPv - losses due to soil washing . Minimum minimum values of gaseous losses of nitrogen fertilizers and soil: for crops of continuous sowing - 10-15, for cultivating crops - 15-20% of the sum of all articles of the arrival of nitrogen in the soil. Nitrogen introduced with seeds, and the removal of this element from the soil with the main and byproducts are determined by reference data: when sowing grain cereal bring about 4-6 kg / ha nitrogen, leguminous - 8-15, etc. Depending on the type and saturation of crop rotation, a 20-50 kg / ha or more is introduced for a given crop rotation with nitrogen seed.

Soil enrichment with biological nitrogen was determined by the formula: Nob = (Mpk 2,5% N) + (MPU% N) • CF - Ny (1 - CF) or Nob = Nb-N, where Nob - soil enrichment with biological nitrogen, kg /Ha; Nb - biological nitrogen of plant residues (kg / ha); 2,5 - coefficient. Nitrogen fixation factor (KF): for clover, lupine, esparzet - 0,7, for alfalfa - 0,8, for pea and wick - 0,6; for sifted residues of leguminous crops 0,3-0,4; and poplar-root residues of legumes - 0,50-0,70. Output of the structure of phytomass was determined by F. I. Levine [10], the supply of nitrogen in the structure of phytomass for AV. Ivoilov [11]. The synthesis of materials and calculations of the results of research was carried out using the "Meded Dispersion Analysis" [12] and the program "STATISTICA" - methods of nonparametric statistics.

Research results. The typical interval of N arrival in crop rotations with a long rotation was 226-314 kg / ha. In the crop rotations Nos. 9 and 12, the income of N exceeded the upper typical typical 110-142% limit, whereas in the crop rotations Nos. 18, 7, 17, 16 the flow of N was less than the typical values. The coefficient of variation (Coef v) was 27.8%. The income of N due to by-products and associative nitrogen fixation varied in the range of 101-151 kg / ha for the CuEF v = 29.9%. For the upper limit of the typical interval, the flow of N was in crop rotations No. 9 and 12, and in the crop rotations No. 7, 18, 17, 16, the flow of N came at a minimum standard value.

1. The balance of nitrogen in grain mills in 7-10 crop rotations for 2005-2015

Code crop rotation	Received nitrogen (kg / ha) from:			Nitrogen consumption (kg / ha):				Nitrogen balance ± kg / ha	Capacity balance sheet kg / ha	Intensity balance sheet	Nitrogen and 1 kg of nitrogen in the crop K
	symbiotic nitrogen fixation	* from the side products	with NPK	the main products	lysis of humus	N_2O	together including mino breaks				
Ten-year crop rotations											
18	53,0	113	204	102	107	2,40	212	-8,00	416	97	0,50
5	36,0	105	236	122	82,0	4,50	235	+1,00	471	101	0,52
17	19,0	90,0	202	97,0	86,0	4,10	206	-4,00	408	98	0,48
12	142	211	446	189	122	5,80	333	+116	471	104	0,43
7	20,0	98,0	222	95,0	96,0	4,60	211	+11,0	433	104	0,43
14	25,0	111	236	104	101	6,30	237	-1,00	473	99	0,44
9	78,5	167	344	152	120	6,20	339	+5,00	683	123	0,44
8	50,0	147	294	142	123	5,90	294	0,00	588	100	0,48
2	26,0	130	258	120	114	5,50	258	-0,00	779	100	0,46
Semiropic crop rotation											

16	50,0	83,0	223	120	110	2,70	229	-6,00	452	97,0	0,53
13	80,0	128	305	167	123	4,70	304	+1,00	609	99,0	0,55
Statistical evaluation of parameters											
Coef.· v,%	69,3	29,9	27,8	24,0	13,7	27,8	19,1	33,8	25.0	7,22	8,86
$HIP_{0.05}$	24,5	24,9	44,0	20,4	9,79	0,88	32,7	23,5	35,0	4,88	0,02

* by-products + cultivars + roots, associative nitrogen fixation - 25 kg / ha

The removal of N main products varied in the range of 108-148 kg / ha for Söf · v = 24%. With the upper limit of typical values (> 148 kg / ha), the removal of N was in crop rotations No. 18, 7, 14. The removal of N was the main output for the minimum typical value directly related (R = + 0.72-0.85) with the formation of productivity and content (R = 0.75-0.78) of digestible protein in the crop.

The consumption of N from humus mineralization was 98-118 kg / ha for SoeF · v = 13.7%. In crop rotations No. 9, 8, 12, 13, the consumption of N due to mineralization of humus exceeded the upper standard limit, whereas in crop rotations No. 7, 17, 5 the consumption of N was lower than the minimum standard value. Total consumption of N in 7-10-crop rotations varied in the typical range of 226-292 kg / ha for Söf · v = 19.1%. Exceeding the standard level of the upper limit of the values of the total removal of N was in crop rotations Nos. 9, 8, 12, 13, and in the crop rotations No. 18, 7, 14, 17 the outflow N went beyond the lower limit of the typical value.

The nitrogen balance (B-N) of the 7-10-cubic crop rotation varied in the typical range of values: B-N = -6: ÷ + 34 kg / ha for Coef = v = 33.8%. For the upper limit, the typical values of B-N were obtained only in crop rotations No. 7 and 12: B-N = + 11-116 kg / ha, while for the lower limit the nitrogen balance level is obtained on the control without fertilizer (No. 18). The typical interval of nitrogen balance intensity values varied from 97% to 107% with low variation: Soef · v = 7.2%. Beyond the upper standard value, the intensity of the balance comes from the crop rotation number 9, where perennial grasses are grown, and the rest of the crop rotation is within the typical values.

The efficiency of soil nitrogen and fertilizer expenditures in the crop rotation considered is estimated by the amount of nitrogen consumed at the expense of the mentioned sources for the creation of unit N in the crop of the above-ground mass (Kef), which is removed from the field. Typical interval of this indicator varies from Kef = 0.46 to Kef = 0.50 kg for Soef · v = 8.9%. The coefficient of nitrogen consumption (Kef) in crop rotations Nos. 18, 5, 13, 16 by their values exceeded the upper standard value limit, indicating that the cost was uneconomical, and in the crop rotations No. 9, 7, 12, 14 the value of Kef was lower than the lower boundary of values, which indicates the most economical nitrogen consumption. The rest of the crop rotation for Kef had an average level of nitrogen utilization. Table 2 shows the nitrogen balance in cereal-seeded 7-10-crop crop rotation with a median value for 2005-2015.

In short-rotation crop rotations, all items of income N changed in the typical range of values of 239-283 kg / ha, which is higher than in the 7-10-crop rotation crop both in the upper and lower typical values. The coefficient of variation was: Soef · v = 19,6%, which is lower in 1,42 times compared with crop rotations with a long rotation. For the upper limit of the typical values of the total flow of N came crop rotations number 15, 15a, 3, 16b, and below the crop rotation: No., 4, 4a, 6a, 3b, 13a. The incoming N from the by-products had a typical interval: 101-136 kg / ha, which was significantly narrowed to the upper typical value compared with 7-10-crop rotations, with Soef · v = 29%. In the crop rotations Nos. 10, 10a, 15a, 3, and 16b, the input of N from the by-product exceeds the upper limit of typical values, and in crop rotations Nos. 4, 4a, 3a, 3b, 13a decreases for the lower boundary of typical values.

The replenishment of articles of nitrogen balance at the expense of symbiotic nitrogen fixation varied in the range of 30-65 kg / ha, which is 1.27 times narrower than the upper typical value for crop rotation with a long rotation, with the value of Coeff = v = 69.3%. For the upper standard limit, the level of symbiotic nitrogen fixation is obtained in crop rows No. 11, 11a, 15a, 3, and below in crop rotations 1, 1a, 4, 4a, 6a, 10. The typical interval of symbiotic nitrogen fixation was 28-77 kg / ha for Soef · v = 69.3%. For the upper limit of the typical values of the flow of N due to nitrogen fixation was in crop rotations Nos. 9, 12, 13, where perennial grass was sown, and in the crop rotations No. 7, 14, 17, 2 the yield of N was less than the minimum typical value. The consumption of N main products in short-rotation crop rotations had a typical interval of values of 96-137 kg / ha, which is 1.08 times (for the upper) and 1.13 times (below the limit) less than 7-10 crop rotations. The coefficient of variation was: Soef · v = 34.8%, which is 1.45 times higher than that of long rotation crop rotations. In the crop rotations Nos. 10a, 11, 15a, 3, and 16b the removal of the

2. The balance of nitrogen in grain-sowing 3-5 rotation for 2005-2015

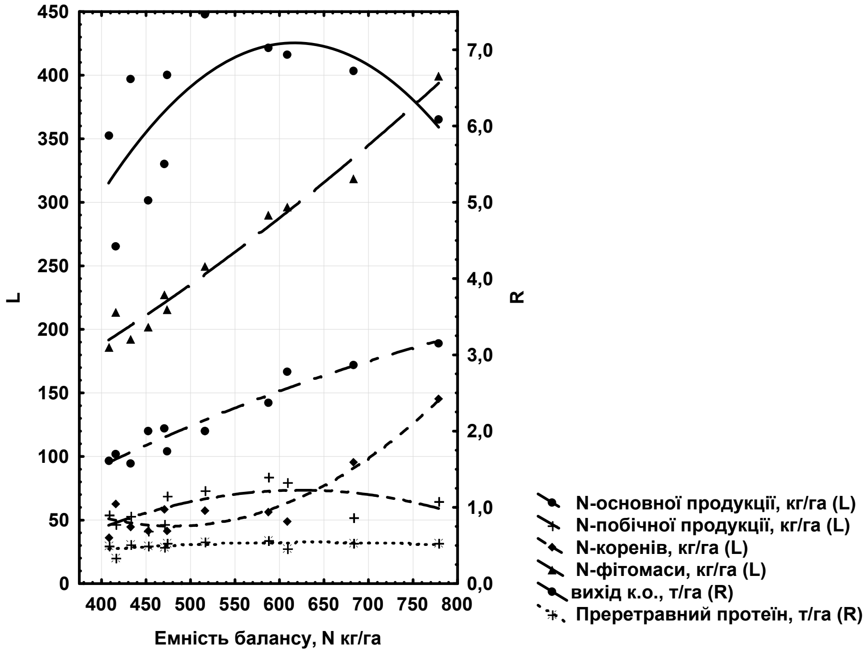
Code the mines	Received nitrogen, kg / ha			Nitrogen consumption (kg / ha)				nitrogen balance, ± kg / ha	Capacity balance sheet kg / ha	Intensity balance sheet %	* Kf
	symbiotic nitrogen fixation	* from the side products,	with NPK	the main one the product	mineralization humus	N_2O	together with mineral fertilizers				
5 pounds											
4	21,0	98,0	210	79,0	83,0	2,1	184	+26,0	394	114	0,38
1	14,0	102	211	89,0	87,0	2,2	205	+6,00	416	103	0,42
11	70,0	113	277	152	89,0	2,3	270	+7,00	547	103	0,55
11a	24,0	118	270	110	103	2,8	241	+29,0	511	112	0,41
4a	27,0	79,0	205	82,0	73,0	1,9	182	+23,0	398	113	0,39
6	34,0	125	259	102	99,0	2,5	227	+32,0	486	108	0,39
6a	23,0	101	226	99,0	92,0	2,3	220	+6,00	446	102	0,41
15	103	133	328	110	121	2,8	244	+84,0	572	134	0,24
1a	17,0	126	248	107	96,0	2,5	230	+12,0	478	108	0,43
10a	33,0	133	263	173	131	2,9	328	-65,0	591	80	0,66
15a	94,0	166	354	199	124	3,1	351	+3,00	705	101	0,56
10	28,0	147	275	121	126	3,0	274	+1,00	549	101	0,44
Four-course crop rotation											
3	118	137	352	190	104	2,2	296	+56,0	648	119	0,54
3- Crop rotation											
13a	43,0	95,0	244	80,0	72,0	2,1	178	+66,0	422	137	0,33
3a	40,0	64,0	231	74,0	71,0	1,1	171	+60,0	402	135	0,36
3б	30,0	67,0	202	72,0	96,0	1,2	201	+1,00	403	100	0,36
16б	43,0	196	344	127	150	2,2	302	+42,0	646	114	0,36
Statistical evaluation of parameters											
$HIP_{0.05}$	16,2	17,5	26,5	20,5	11,6	0,31	27,8	17,5	25,0	7,43	0,04

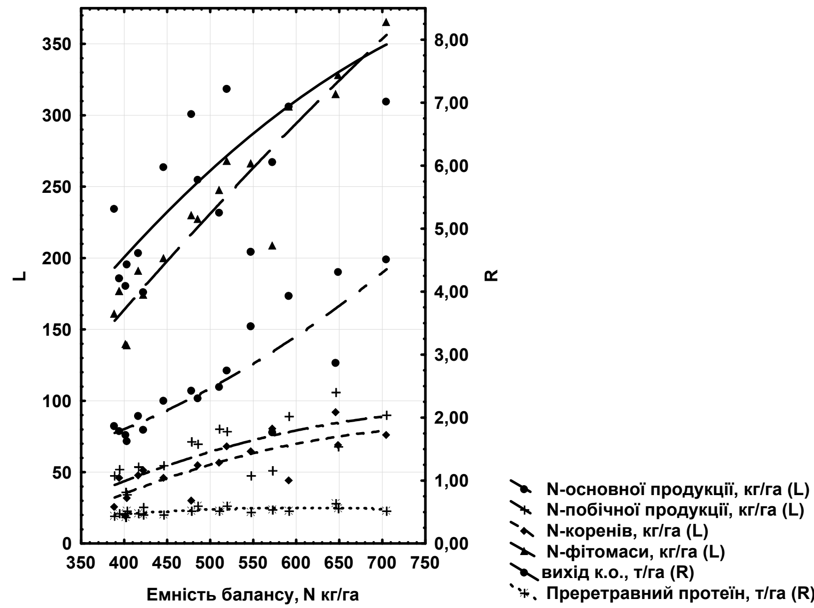
Note: * KF-costs of total nitrogen and 1 kg of nitrogen in the crop.

N main product exceeded the upper standard limit, and in the crop rotations Nos. 1, 4, 4a, 3a, 3b, 13a the take-off N declined beyond the boundary of the typical range of values. Costs of N due to the mineralization of humus were at the level of 7-10-cubic meters of crop rotation for the growth of Soef · v to 22.4%, which is 1.64 times higher compared with 7-10-crop crop rotations.

The highest costs of N due to mineralization of humus were in crop rotations Nos. 10, 10a, 15, 15a, 16b, while the lowest expenditures N in crop rotations No. 1, 4, 4a, 11, 3a, and 13b. Total expenditures N narrowed to an interval of values of 213-268 kg / ha, which is significantly less than the crop rotations with long rotation. The coefficient of variation of the indicator was: Soef · v = 22,6%. N removal exceeded the upper limit of typical values (> 268 kg / ha) in crop rotations Nos. 10, 10a, 11, 15a, 3, 16b, and in crop rotations Nos. 4, 4a, 3a, and 13a - declined below the total value of the total removal N: <213 kg / ha. The balance of N short-term crop rotation was estimated at a positive interval of values: B-N = + 5,40 ÷ + 40 kg / ha for a high Sof · v> 100% value, which drastically distinguishes short-rotation crop rotations from crop rotation with long rotation. Only in the 5-way crop rotation (No. 15, 3, 3a, 13a, 16b) B-N exceeds the upper limit of typical values (B-N> +40.4 kg / ha), and in crop rotations No. 10, 15a, 3b BN was below the minimum standard value (B-N <+5.4 kg / ha). In crop rotation №10a Б-N decreased to +65 kg / ha.

The assessment of the B-N by the intensity indicator (Ib) showed that the typical change interval is 104-118%, which is more intensive in 1,07-1,10 times compared with crop rotations with long rotation. The coefficient of variation for Ib in short rotation crop rotations is 13.1%, which is 1.81 times higher in comparison with the rotation crop rotation group. Only in the crop rotations 15, 3, 3a, 13a, 16b Ib exceeded the upper typical value (Ib> 118%), and in the seven crop rotations Ib was lower than the lower standard value (Ib <104%).





EB-N: N-basic products, kg / ha: y = -9.36 + 0.26 * x; r = 0.86; r2 = 0.74

EB-N: N-basic products, kg / ha: y = -62.6 + 0.35 * x; r = 0.85 r2 = 0.72

7-10-strong crop rotations	3-5 cubes of crop rotation
EB-N: N-by-products, kg / ha: y = 33,3 + 0,05 * x; r = 0.65; r2 = 0.43	EB-N: N-by-sideproduct, kg / ha: y = -18,9 + 0,17 * x; r = 0.74 r2 = 0.55
EB-N: N-roots, kg / ha: y = -55.1 + 0.22 * x; r = 0.85; r2 = 0.72	EB-N: N-roots, kg / ha: y = -26.2 + 0.16 * x; r = 0.79; r2 = 0.62
EB-N: N-phytomass, kg / ha: y = -31,4 + 0,54 * x; r = 0.84; r2 = 0.71	EB-N: N-phytomass, kg / ha: y = -90.9 + 0.64 * x; r = 0.84; r2 = 0.71
EB-N: output of the cp, t / ha: y = 4,59 + 0,004 * x; r = 0.65; r2 = 0.43	EB-N: output, rpm, t / ha: y = -0,021 + 0,013 * x; r = 0.79; r2 = 0.62
EB-N Permeated protein, t / ha: y = 0.41 + 0.002 * x; r = 0.58 r2 = 0.35	EB-N: Permeated protein, t / ha: y = 0.34 + 0.001 x; r = 0.66; r2 = 0.44

Fig. 1. Dependence of productivity and nitrogen supply in the components of the total phytomass from Yeb-N in non-rotation crop rotations

The least effective N was used in crop rotations No. 10a, 11, 15a, 3, and most effectively in crop rotations Nos. 4, 15, 3a, 3b, 13a, 16b, where Ke was> 0.47 kg / ha, in the first fall, and Ke <0.39 kg / ha, in the other.

The capacity of the nitrogen balance (YeB-N) is a quantity that characterizes the amount of colloid substance and, accordingly, the higher the level of this value, the more intensive crop rotation [13]. In the 7-10-crop rotation crop, the typical interval of variation of EB-N is 456-621 kg / ha for Soeff · v = 22.9%. In crop rotations No. 9, 12 Ye-N exceeds the upper standard limit of values (683 and 773 kg / ha), whereas in crop rotations No. 18, 7, 17, 16 EB-N went beyond the lower typical value (EB-N <456 kg / ha). In 7-10-crop rotations, the flow of N to the crop rotation agrocentose correlates (R = + 0,92 ± 0,03) with the take-off N as the main product. This is a crop rotation with saturation of perennial herbs, EB-N is 700-800 kg / ha, and in crop rotations where the saturation of beans and perennial herbs is low or absent, EB-N is reduced to 400-500 kg / ha. In typical crop rotations with a short rotation (3-5 pounds), the typical variation interval of EB-N was 454-557 kg / ha, which was 1.12 times lower (-70 kg / ha), compared with the 7-10- free crop rotation at an equal value for the lower typical limit. In the crop rotations No. 10a, 15, 15a, 3, 16b, Ye-N exceeds the maximum typical value (YeB-N = 572-705 kg / ha), and in crop rotations No. 1a, 4, 4a, 6a (5-plow) and 3a , 3b, 13a (3-sided) EB-N goes beyond the minimum typical value. The authenticity of the established regularity is evidenced by the value of reliability (R_2) of the exponential equations of the change in the intake and nitrogen extraction in non-rotational crop rotations: R2 = 0.69-0.96. With the capacity of the nitrogen balance, the connection between the intake and removal of nitrogen was at the level of direct strong correlation (Fig. 1-2). In 7-10-crop rotations, the flow of N to the crop rotation agrocentose correlates (R = + 0,92 ± 0,03) with the take-off N as the main product. This is a crop rotation with saturation of perennial herbs, EB-N is 700-800 kg / ha, and in crop rotations where the saturation of beans and perennial herbs is low or absent, EB-N is reduced to 400-500 kg / ha. In typical crop rotations with a short rotation (3-5 pounds), the typical variation interval of EB-N was 454-557 kg / ha, which was 1.12 times lower (-70 kg / ha), compared with the 7-10- free crop rotation at an equal value for the lower typical limit.

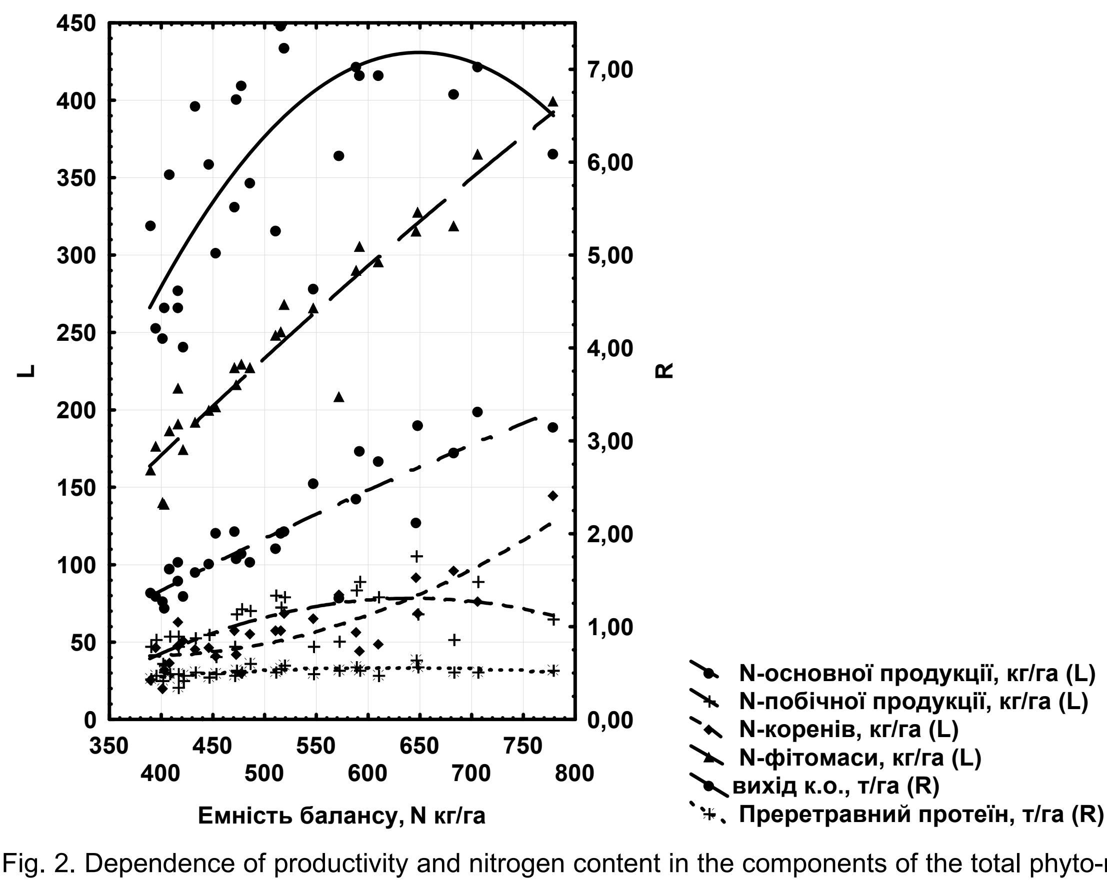


Fig. 2. Dependence of productivity and nitrogen content in the components of the total phyto-mass from EB-

N in non-rotation crop rotation-the general model.

In the crop rotations No. 10a, 15, 15a, 3, 16b, Ye-N exceeds the maximum typical value (YeB-N = 572-705 kg / ha), and in crop rotations No. 1a, 4, 4a, 6a (5-plow) and 3a , 3b, 13a (3-sided) EB-N goes beyond the minimum typical value. The authenticity of the established regularity is evidenced by the value of reliability (R^2) of the exponential equations of the change in the intake and nitrogen extraction in non-rotational crop rotations: R^2 = 0.69-0.96. With the capacity of the nitrogen balance, the connection between the intake and removal of nitrogen was at the level of direct strong correlation (Fig. 1-2). Regardless of the rotational and economic type of crop rotation, EB-N correlated with all the articles of the balance N at the level of medium and strong direct correlation (Fig. 3):

EB-N, kg / ha: N-basic products, kg / ha: y = -36.8 + 0.30 * x; r = 0.86; r2 = 0.73

EB-N, kg / ha: N-by-products, kg / ha: y = 5.58 + 0.11 * x; r = 0.65; r2 = 0.45

Ye-N, kg / ha: N-roots, kg / ha: y = -39.3 + 0.19 * x; r = 0.83; r2 = 0.69

Ye-N, kg / ha: N-total phytomass, kg / ha: y = -60.9 + 0.58 * x; r = 0.83; r2 = 0.69

EB-N, kg / ha: output, rpm, t / ha: y = 1,85 + 0,01 * x; r = 0.68; r2 = 0.46

EB-N, kg / ha: feed-protein unit, t / ha: y = 0,37 + 0,0003 * x; r = 0.51; r2 = 0.26

Based on the regression coefficients of the dependence equations of EB-N on the components of total phytomass and on the productivity of crop rotation, it was found that in 7-10 crop rotations per unit of EB-N there are 0.26 output units of basic products, 0.54 units of total phyto-mass, 0.004 units of exit and 0.002 units of digestible protein. For 3-5-crop crop rotation, the EB-N cost for output of main products was 1.35 times higher, total body mass - 1.56 times, cu - 3.25 times, digestible protein is 2 times more compared with 7-10 crop rotations, which indicates a more intense circulation of N in the absence of perennial grasses in the structure of crop rotation. In crop rotations with a long rotation, the cost of EB-N for the formation of by-products was 0.05 units, and the roots were 0.22 units (1 to 17), and in 3-5-crop rotation crops, on the contrary: the unit EB-N accounted for 3 , A 4 times higher yield of by-products and a 1.38 times lower yield of root mass (1 to 4.5), indicating an optimization of the ratio of the structure of the total non-market phytomass (Fig. 1). When the amount of nitrogen in the byproducts is reduced to 20-25 kg / ha, the balance between immobilization and mineralization of nitrogen in agrocenoses of uneven crop rotation [14] is disturbed, but all the variants of crop rotation that were investigated exceeded this criterion.

Findings.

1. In the 7-10-crop rotation crop, the typical interval of the change of EB-N is 456-621 kg / ha with a coefficient of variation of 22.9%, and the flow of nitrogen in the crop rotation agrocentose correlates (R = + 0.92 ± 0.03) with removal of nitrogen by main products. At the same time, the capacity of the balance at the level of direct strong correlation is associated with the growth of productivity. Maximum productivity of crop rotation at the exit of the c. and feed-protein units is achieved with a balance capacity of over 580 kg / ha.

2. In the 3-5-crop rotation crop, the nitrogen balance in all crop rotation options was positive, and the capacity of the balance at maximum yield in the yield of both crude oil and grain protein units was 590-705 kg / ha. In the 7-10-free crop rotation, the ratio of nitrogen withdrawal to incomes tends to favor sequestration, whereas in 3-5-crop rotations, on the contrary, in favor of nitrogen input. Productivity of short-rotation crop rotation at the output of the c. from 1 ha closely correlated with the articles of nitrogen (R = + 0,75-0,83 ± 0,03) and its cost (R = + 0,69-0,78 ± 0,03), whereas In crop rotations with a long rotation, the productivity correlated with the components at the level of average values.

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