UDC 631.416.1:631.582-026.29(477.5)

Carbon-nitric turnover in agrocnoses of crop rotations

Demidenko O.[1], **Shapoval I.**[2], **Boiko P.**[3], **Velychko V.**[4]

[1, 2]Cherkassy state agricultural experimental station of NSC «Institute of agriculture of NAAS», Dokuchayev Str., 13, Kholodnianske, Smilianskyi region, Cherkassy oblast, 20731, Ukraine, [3]NSC «Institute of agriculture of NAAS», Mashynobudivnykiv Str., 2b, Chabany, Kyiv-Svitoshyn region, Kyiv oblast, 08162, Ukraine, [4]NSC «A.N.Sokolovsky Institute of soil science and agrochemistry of NAAS», Chaikovska Str., 4, Kharkiv, 61024, Ukraine; e-mail: [1−2]smilachipv@ukr.net, [3]izaan@ukr.net, [4]agrovisnyk@ukr.net

The purpose. To determine normative parameters of typification of balance and content of organic carbon C_{org} in agrocnoses of different crop rotations, as components of methodology of agroecological assessment of their productivity at use of collateral production as organic fertilizers in conditions of modern climatic system of Forest-steppe of Ukraine. **Methods.** Generalization of results of long-term researches in field stationary experiment, statistical: dispersive, correlation, factorial, claster analysis of parameters of productivity, qualitative and quantitative clauses of balance of nitrogen, carbon. **Results.** At full leaving of collateral production in 7 – 10-field crop rotations balance of C_{org} was positive, and the maximal productivity coincided with high values of balance (+1,32 – 2,54 t/hectare) and capacity of balance (3,17 – 3,72 t/hectare). In 3 – 5-field crop rotations balance of Corg was less profitable (+0,56 – + 0,87 t/hectare), but also capacity of balance of C_{org} increased at the maximal productivity up to 4,01 – 4,12 t/ hectare. Direct correlation is fixed between capacity of balance of C_{org} and productivity of crop rotations. With growth of productivity of crop rotations proportionally grows both mineralization, and humufication of C_{org}. Capacity of balance in short crop rotations on the maximal parameters exceeds 4 t/hectare whereas at 7 – 10-field crop rotations the maximal value of capacity of balance is less 4 t/hectare. **Conclusions.** Ratio C_{org} to nitrogen in agrocnoses, irrespective of type of crop rotations, is in optimum limits (20 – 30:1), that creates optimum conditions for humifacation of collateral production and formation of humus. It is confirmed by balance calculations of nitrogen and organic carbon.

Key words: *balance of organic carbon, capacity of balance, productivity, different crop rotations, correlation, factorial analysis.*

https://doi.org/10.31073/agrovisnyk201809-10

The turn of nitrogen and carbon - are the main biogeochemical cycles that occur in agroecosystems [1,2]. The shortage of nitrogen in agricultural crops in crop rotation negatively affects their productivity, weakening the carbon sequestration of the atmosphere, which exacerbates the effects of global climate change [3,4,5]. Generally, the inclusion of the carbon cycle of agroecosystems into climatic models as an integral characteristic of the carbon cycle in the atmosphere [6], and the exclusion of the nitrogen cycle from nitrogen-carbon circulation and the consideration of the effects of climate change leads to an inadequate assessment of the response of agro-ecosystems, where the mineral forms of soil nitrogen is limiting a factor for the development of plants, as in natural coenoses [7,8,9], and in agrocenoses [10].

The stronger the connection between the productivity of natural coenoses and agrocenoses with the amount of collected nitrogen from the soil, the faster the CO2 emissions are absorbed by agrophytocenoses [11,], and therefore the quantitative assessment of the interconnection of carbon and nitrogen cycles significantly affects the assessment of the increase or decrease of the carbon budget of agro-ecosystems [12,13] and has a significant effect on the change in the content of nitrogen and carbon in the vegetation, the layer of detritus and organic matter of the soil [10, 14,15]. Thus, the development of a comprehensive model of nitrogen conversion using crop rotation types with carbon traffic is relevant and provides an opportunity to obtain a reliable estimate of carbon turnover in anticipated climatic changes and to identify the basic patterns of the restoration of natural soil formation in the agro-crops of the forest-steppe of Ukraine.

The aim of the study. To establish normative parameters of typing the balance and content of organic carbon in agrocenoses and to establish the basic laws of nitrogen-carbon circulation in uneven crop rotation as a component of the methodology of agroecological assessment of their productivity in the conditions of the forest-steppe of Ukraine.

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

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 test is located on the chernozem with a typical low-humus volumetric acid with a humus content of 3.8-4.2%, a content of mobile phosphorus - 120-140 mg per 1000 g soil, moving potassium - 80-100 mg per 1000 g of 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. Method of cultivating crop rotation-differentiated.

Calculation of carbon balance in agrocenoses different types and prediction of the humus state of chernozems by mass of C-CO2 released, carried out in the following flows:

Cγ - weight of carbon Sorg, due to mineralization of humus, t / ha;

Wed - weight of carbon Sorg., Due to mineralization of by-products, pericarp and root residuals, t / ha;

C (γ + p) - total weight Sorg as a result of mineralization, t / ha

Cj - mass of carbon Sorg, due to the respiration of soil microorganisms, t / ha.

Determination of the level of potential bio-productivity of crops by the resource of organic carbon is carried out by the balance of the given resource, and the balance of Sorg itself is defined as the difference between the arrival of Sorg to agrocenosis and its involvement from the by-products of humus. The expense article includes the removal of Sorg by harvest, the mass of Sorg by-products due to mineralization. For ease of calculation, Cj was accepted as a constant for all variants. The carbon balance is calculated according to the generally accepted method of taking nitrogen (N) according to the yield of crops, and based on these calculations the balance of N in agricultural crops is calculated and the recommendations for the development of the official publication "The Sixth National Communication of Ukraine on Climate Change, 2012". The nitrogen balance is calculated according to the generally accepted method [9].

In a stationary experiment in the presence of crop rotation:

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 spike); 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

3b 66% -grains (33% - spring wheat); 34% - soybeans

16th to 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; # №13а-16в - 3 crop rotations.

Research results. Sorg content in the main products varied in the range of 4,04-8,48 t / ha by the coefficient of variation (Soef.v) Soef.v = 53.6%. In the crop rotations No. 5 and No. 16, the Sorg content exceeded the maximum typical values (Sorg = 11.8-13.3 t / ha); in Crop No.18, 14, 17, 13, the Sorg content was smaller than the lower limit of the typical content (Sorg <4.04 t / ha). In the rest of the crop rotation, the Sorg content was in a typical range of values.

The content of Sorg in the by-products and roots varied in the range of typical values of 5.60-7.01 t / ha in the ratio of by-products to the mass of the roots of 2.21-2.26 to 1. The coefficient of variation in the weight of the by-product along with the roots was 16, 9%, and article-specific - Soef.v = 30.6% and Soef.v = 28.1% respectively. By the output of by-products the most productive were crop rotations No. 9, 2, 13, and with the growth of the root mass of crop rotation No. 8, 12. In crop rotations No. 9, 8, 12, the total content of Sorg exceeded the upper standard limit (7.1 t / ha), and in Crop No.18, 7, 17, 13 the Sorg content was less than 5.6 t / ha. The content of Sor in total phytomass varied in the typical range of values: 10-15 t / ha by the coefficient of variation of 29.5%. The highest content of Sorg in the total phytomass was crop rotation No. 5 and 16 (> 15 t / ha), and in the four crop rotations (No. 18, 14, 17, 13) the accumulation of Sorg was least efficient (<10 t / ha).

The typical interval from the mineralization of humus was 1.13-1.43 t / ha, with a slight deviation from the mean value: Soef · v = 19.1%. The highest level of humus mineralization was found in crop rotations Nos. 9, 8, 12, 16 (Sorg > 1.43 t / ha), and in the five crop rotations (No. 18, 7, 17, 2, 13), the mineralization of humus was less than the lower limit of typical values (Sorg <1.13 t / ha). The interval of change from mineralization of sorga was significantly higher in 1.14-1.15 times the absolute value than the interval of change in the content of mineralization of humus. The most effective humming of by-products was in crop rotations with saturation of perennial herbs and grain-leguminous crops (No. 9, 8, 12, 2, 16), and in crop rotations No. 18,7, the level of accumulation of Sorg due to humification is reduced beyond the minimum standard value (<1.29 t / ha).

The Sorg balance in the 7-10-crop rotation varied in a positive range of values, only the crop rotation No. 18 (control without fertilizers) had a negative Sorg balance.

In the crop rotation with high saturation of perennial herbs and beans (Nos. 9, 8, 12), the Sorg equilibrium exceeded the maximum typical value (BSorg> 1.23 t / ha), while in the rest of the crop rotation, except for Nos. 18 and 16, the Bargorg was higher than the minimum typical value. The intensity of the balance of Sorg in the group of 7-10-crop rotation was within the typical interval (Ib = 108-116%), only in the control without fertilizers (No. 18) and in the crop rotation number 16, the balance intensity went beyond the lower standard value (Ib < 108%).

2. The content of organic carbon in the components of total phytomass and carbon balance in 7-10 volumes crop rotations for 2005-2015

Code the grass mines	Organic carbon content, Sorg, t / ha				Cork mineralization t / ha	C orgh rubberization sideways products, t / ha	Balance: C org t / ha	Capacity balance sheet t / ha	Intensity balance sheet %	C orgh to N
	the main thing product	side by side	the roots	*together						
10 piles of crop rotation										
18	3,7	3,1	1,8	8,6/4,9	1,07	1,06	-0,06	2,13	99	31:1
5	11,8	3,5	2,1	17,6/5,8	1,17	1,44	+0,270	2,61	123	23:1
17	3,8	3,4	1,6	8,8/5,0	1,10	1,30	+0,20	2,41	115	22:1
12	5,8	5,0	1,9	12,7/6,9	1,12	1,61	+0,49	2,79	113	21:1
7	6,7	3,9	1,6	12,2/5,5	1,05	1,17	+0,12	2,21	111	19:1
14	2,9	4,6	1,8	9,3/6,4	1,20	1,40	+0,20	2,60	118	18:1
9	6,4	5,9	2,0	14,4/8,0	1,52	1,65	+1,32	3,17	108	20:1
8	4,5	4,8	2,7	12,0/7,5	1,48	1,73	+2,54	3,21	117	22:1
2	6,0	3,6	3,6	13,2/7,2	1,76	1,96	+1,98	3,72	111	22:1
7 miles of crop rotation										
16	13,3	5,1	1,86	20,1/6,9	1,52	1,60	+0,08	3,12	105	21:1
13	4,0	8,0	1,86	9,3/5,3	1,11	1,27	+0,16	2,38	114	25:1
Statistical evaluation of parameters										
Mean	6,26	4,63	2,07	6,31/12,5	1,28	1,47	0,66		112	22:1
C.v,%	53,6	30,6	28,1	16,9/29,5	19,1	18,1	132		5,86	15,7
$HIP_{0.05}$	2,22	0,95	0,41	0,71/2,46	0,15	0,18	0,57		4,36	2,31

* numerator - in all phytomass; denominator - by-product + roots

The value of Corg to N varied in the range from 20 to 1 to 24 to 1 with a slight variation of the parameter: Soef · v = 15.7%. The Sorge to N ratio, which exceeded the upper standard limit, was found in crop rotations Nos. 18 and 13, and below the limit of the minimum typical value of the Sorge to N ratio, there were crop rotations No. 7, 14. Table 2 shows the content of Sorge in the components of the total phytomass and the Sorg equilibrium in 7-10 crop rotations in median value, and Table 3 shows the content of Sorg in the components of total phytomass and the Sorg equilibrium in 3-5 crop rotations in terms of the median value for 2005-2015.

In short-rotation crop rotations, the Sorgh typed stock in main products was 2.20-4.18 t / ha, which is 1.8-2.03 times narrower with respect to the ratio of 7-10-crop crop rotation. The coefficient of variation increased to 58.6%. In the five crop rotations (No. 1a, 6a, 10a, 15a, 3), the stock of Corg in the main products exceeded the maximum typical value (> 4.18 t / ha), and in seven crop rotations (No. 4, 6, 10, 11, 3a, 3b, 13a) the margin was below the limit of the lower typical value (<2.20 t / ha). By the content of Sorg in the by-products, the typed interval is formed: 3.39-4.65 t / ha, which is more narrowed than 7-10-crop crop rotations. The coefficient of variation was 30.6%. Sorgh stock at the root in the typed range of values was 1.88-2.68 t / ha, which is more narrowed relative to the group of crop rotation with long rotation.

The ratio of the stock of sorga of by-products and roots was 1.75-1.80 to 1, which was more narrowed (2.21-2.25 to 1) relative to crop rotation with a long rotation.

Typified margin of Sorgh of by-products and roots as a whole was 5.37-6.99 t / ha with a higher coefficient of variation of 35%. The stock of Sorg in the total phytomass was 7.67-11.0 t / ha versus 10.0-15.0 t / ha in 7-10-crop rotation crops, and the Corg stock in the total phytomass exceeded the upper standard line in crop rotations No. 1, 15a, 3, 16b, and in crop rotation no. 4, 3a, 3b, 13a declined beyond the minimum typical values.

3. The content of organic carbon in the components of total phytomass and the carbon balance in 3-5 species crop rotations for 2005-2015

Code the grass mines	Organic carbon content, Sorg, t / ha				Cork mineralization t / ha	C orgh rubberization sideways products, t / ha	Balance: C org t / ha	Capacity balance sheet t / ha	Intensity balance sheet %	C orgh to N
	the main thing product	side by side	the roots	*together						
Five crop rotations										
4	1,2	3,2	2,2	6,6/5,4	1,08	1,48	+0,40	2,56	138	22:1
1	3,2	5,0	2,2	14,0/7,0	1,24	1,61	+0,36	2,85	130	30:1
11	2,2	3,0	3,0	8,0/5,8	1,07	1,15	+0,08	2,21	108	22:1
11a	4,0	4,2	1,8	9,8/5,8	1,21	1,46	+0,26	2,67	122	19:1
4a	4,0	4,2	1,2	9,4/5,4	0,98	1,16	+0,18	2,46	114	25:1
6	1,4	4,2	3,6	8,0/6,6	1,14	1,84	+0,70	2,98	161	24:1
6a	6,4	3,6	1,6	11,0/5,0	1,06	1,15	+0,09	2,21	108	20:1
15	2,8	5,0	3,0	11,0/8,4	1,81	1,95	+0,14	3,76	106	24:1
1a	4,4	5,2	1,2	11,0/6,4	1,26	1,50	+0,24	2,76	118	58:1
10a	4,6	4,6	1,8	11,0/6,4	1,52	1,58	+0,07	3,10	104	27:1
15a	5,4	3,0	4,0	12,0/7,0	1,44	2,00	+0,56	3,44	139	22:1
10	1,8	5,0	2,2	8,0/7,2	1,57	2,44	+0,87	4,01	156	22:1
4 free crop rotation										
3	6,5	6,25	2,75	15,3/8,8	1,54	2,00	+0,46	3,54	130	30:1
3 miles of crop rotation										
13a	1,1	2,3	2,0	5,3/4,3	0,83	1,13	+0,30	1,96	136	17:1
3a	1,3	2,3	1,3	5,0/3,7	0,82	1,07	+0,26	1,89	132	20:1
3б	1,0	2,0	1,3	2,6/3,3	0,72	1,03	+0,33	1,75	143	20:1
16б	2,3	5,3	3,0	10,7/8,3	1,73	2,37	+0,63	4,12	157	20:1
Statistical evaluation of parameters										
C.v,%	58,6	30,6	38,2	27,5/35,0	26,1	28,5	66,2		14,2	37,4
$HIP_{0.05}$	0,95	0,63	0,44	0,81/1,67	0,17	0,23	0,13		9,41	4,75

* numerator - in all phytomass; denominator - by-product + roots

The typical variation interval of the sorgo from the mineralization of humus in 3-5-crop rotations was 1.07-1.41 t / ha with an average value of 1.24 t / ha and a variation coefficient of 26.1%, which is somewhat worse than crop rotation from long rotation. Thus, the coefficient of variation increased by 1.36 times, and the lower typical mineralization value of the deviation increased by 5%. The group of crop rotation was determined (№1a, 10, 10a, 15, 15a, 3, 16б), where the mineralization of humus exceeded 1.41 t / ha, and in the crop rows No. 10, 10a, 15, 16b the mineralization level was 1.52-1 , 81 t / ha, which was not observed in the crop rotation group with a long rotation. A group of crop rotation with a low level of humus mineralization (No. 4a, 6a, 3a, 3b, 13a) was established, where the mineralization was 0.72-0.98 t / ha.

Typified interval The amount of gumming of by-products was 1.35-1.82 t / ha, which is significantly higher in 1.05-1.10 times compared with long rotation crop rotations. The expansion of the interval values of mineralization is associated with an increase in the coefficient of variation in the level of rubberization of by-products, which increased 1.58 times. A group of crop rotations (№6, 10, 15, 15a, 3, 16b) was found, where the level of humification reached 1.84-2.44 t / ha, which significantly exceeds the level of humification of crop rotation with long rotation. Between the mineralization of the organic matter of humus and the humification of by-products, a direct correlation connection was found for 7-10-crop rotation: R = 0.74 ± 0.03, and for short-term crop rotation, R = 0.87 ± 0.03. It was also found that between the processes of mineralization, humification and productivity, there is a direct correlation dependency for crop rotation with a long rotation R = 0,62-0,66 ± 0,02 at the level of the average level, and in the crop rotations with a short rotation the bond increases in 1 , 18-1,29 times and reaches the values R = + 0,78-0,80 ± 0,02.

Sorg equilibrium in 3-5-crop crop rotation was positive with a typical interval value Δ = + 048 ÷ + 0.22 t / ha at Coef.v = 66.2%. The average value of the Sorg equilibrium was 1.88 times smaller (+0.35 t / ha), and the intensity of the balance varied in the typical range of values 121-139% with a low value of the coefficient of variation (Coeff.v = 14.2%).

The analysis of the ratio of organic carbon in agrocenoses korotkorotatsiynyh rotation to nitrogen showed that the average ratio was 25 to 1, and typical values range varied from 30 to 1 to 20 to 1 in Soef.v = 37.4%. Compared with crop rotations with a long rotation average of the ratio of sorghum to N increased by 114%, and the range of typical values for interval upper grew by 125%. At the same time, the coefficient of variation increased by 2.38 times. As in 7-10-crop rotation crops, and in 3-5-crop rotations, the Corg to N ratio was in the optimal range of values (about 25 to 1). Extension of the Corg to N ratio for crop rotation with long rotation is due to the saturation of their perennial herbs. There criterion according to which, when the soil organic matter comes at a ratio of C: N> 30-40 by lack of nitrogen lost a lot of carbon into the atmosphere through respiration, and at a ratio of C: N <10-20 the lack of sorghum humification ratios are reduced. According to the criteria only rotation №1, 1a, 3 carbon to nitrogen ratio was 27-30 to 1, which requires planting green manures to bring the ratio to 25 to 1. Found rotation group (№6a 11a, 13a, 3a, 3b) where the ratio of carbon to nitrogen is 17-20 to 1, which requires the additional attraction of Sorg to enhance the rubberization of by-products.

Estimated capacity balance sorghum (sorghum-Yemb.) in agrocenoses korotkorotatsiynyh rotation showed that typed interval of change is 2,46-3,22 t / ha, which is slightly wider compared with crop rotations with a long rotation while increasing the coefficient of variation to 25.9 % Correlation between Yamb-Sorg and productivity of 3-5-crop crop rotation reaches R = 0,76-0,82 ± 0,02. With increasing productivity of crop rotation, both mineralization and Sorghum humification increase proportionally. Capacity balance korotkorotatsiynyh rotation for maximum values exceeding 4 tonnes / ha (№10, 16b), whereas when the content of the fields 7-10-rotation maximum value Yemb.-Sorgue is less than 4 t / ha.

In the general connection model it was established that there is a direct correlation between the Emb.-Sorg and the capacity of the balance N (Emb.-N)

(R = 0,72 ± 0,003; R2 = 0,52), and the unit cost Umb.-Sorg accounts for 120 units of Emb.-N, indicating a close relationship between nitrogen and carbon traffic in agrocenoses of unequal crop rotation (rice 1). In the long and short rotation crop rotations, the connection between the indicated indicators was also at the level of direct strong correlation relations, indicating the conjugation of the nitrogen-carbon flow regardless of the rotation of the crop rotation. However, it was found that a direct correlation between RB = 0,74 and

0,78 ± 0,003, R2 = 0,55-0,61, and the unit cost of Emb was found between Humbry-N and Sorgh from mineralization of humus .-N accounted for 0.003 units of Sorghum from honey mineralization in short rotation crop rotation and 0.002 Sorg units in crop rotations with a long rotation, which is 1.5 times less. Between Jemb.-N and Sorgh of the gumming of by-products there is a direct strong correlation (R = 0.70-0.75 ± 0.003; R2 = 0.49-0.66) irrespective of rotational and crop rotation type.

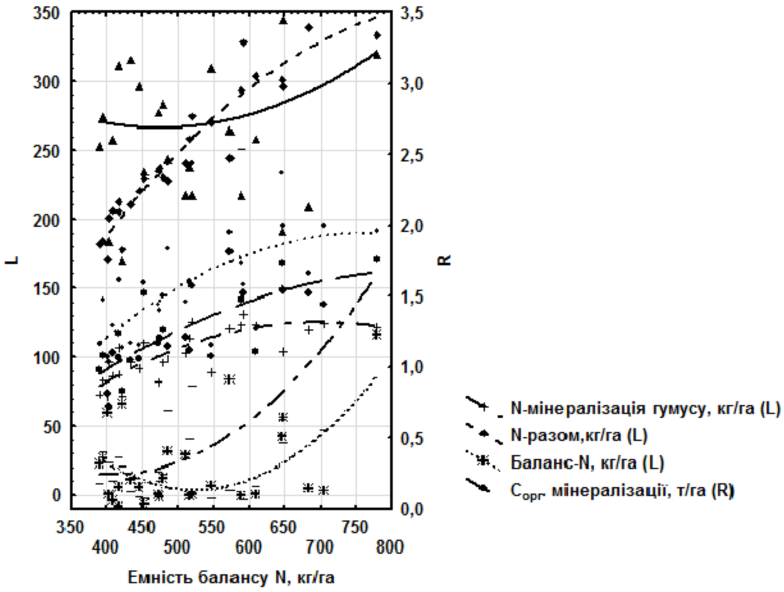
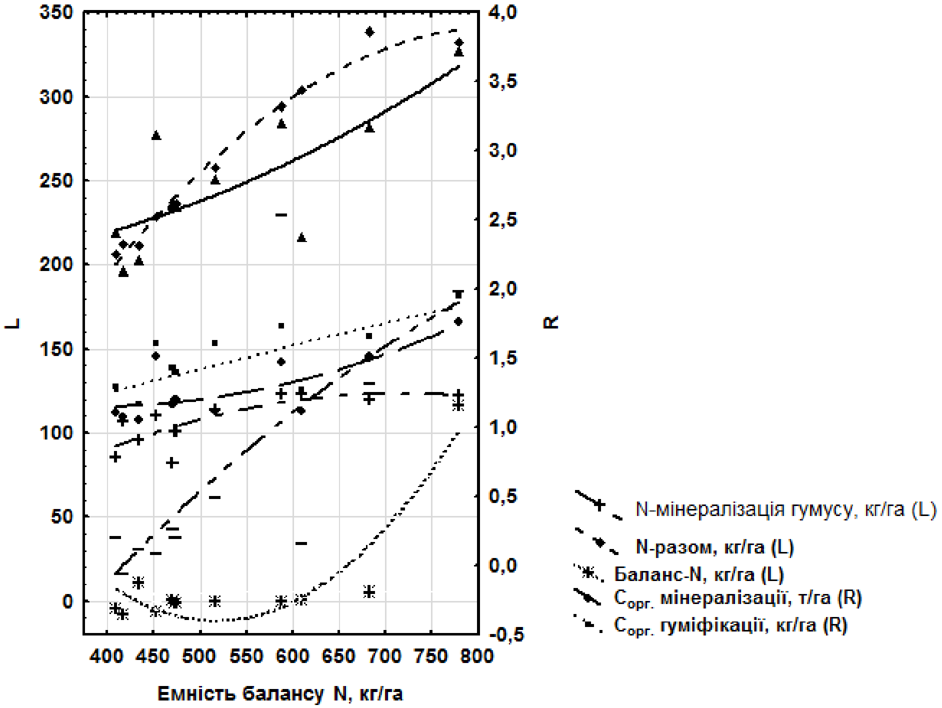
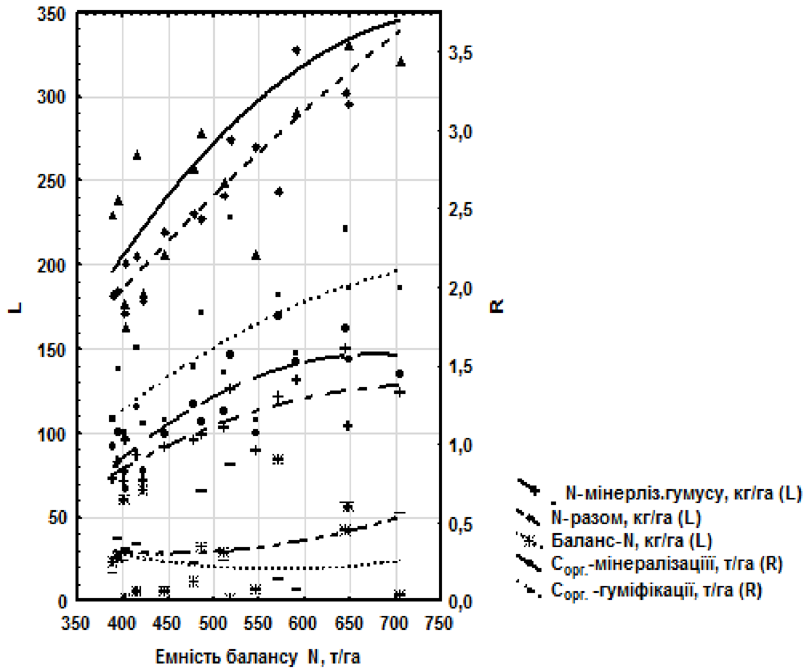


Fig. 1 Dependence of the capacity of the nitrogen balance with the main articles of nitrogen-carbon treatment in non-rotational rotational crops (general model).

However, it was found that a direct correlation between RB = 0,74 and 0,78 ± 0,003, R2 = 0,55-0,61, and the unit cost of Emb was found between Humbry-N and Sorgh from mineralization of humus .-N accounted for 0.003 Sorgh units from humus mineralization in short rotation crop rotations and 0.002 Sorg units in crop rotations with a long rotation, which is 1.5 times less.





7-10 pounds (A) **3-5 pounds (B)**

Emb-N: N-min.hum, kg / ha: y = 60,1 + 0,09 * x; r = 0.75;
Emb-N: N2O: y = 1.21 + 0.007 * x; r = 0.65;
Emb-N: N-together, kg / ha: y = 49,2 + 0,39 * x; r = 0.85;
Emb-N: Balance-N: y = -100.9 + 0.21 * x; r = 0.72;
Emb-N: Sorge (miner): y = 0,49 + 0,002 * x; r = 0.74;
Emb-N: Sorg (rubber): y = 0,59 + 0,002 * x; r = 0.75;
Emb-N: Sorg equilibrium: y = -2,20 + 0,005 * x; r = 0.74;
Emb-N: Emb-Sorge: y = 1,11 + 0,003 * x; r = 0.76;

Emb-N: N-min.hum, kg / ha: y = 10,05 + 0,18 * x; r = 0.79;
Emb-N: N2O: y = 0.58 + 0.003 * x; r = 0.62;
Emb-N: N-together, kg / ha: y = -18,2 + 0,51 * x; r = 0.83;
Emb-N: Balance-N: y = 35.0 - 0.024 * x; r = -0.07;
Emb-N: Sorge (miner): y = -0,03 + 0,003 * x; r = 0.78;
Emb-N: Sorge (rubber): y = 0.013 + 0.003 * x; r = 0.69;
Emb-N: Sorg equilibrium: y = 0,051 + 0,001 * x; r = 0.28;
Emb-N: Emb-Sorge: y = 0.11 + 0.005 * x; r = 0.73;

Fig.2 Dependence of the capacity of the balance of nitrogen with the main nitrogen-carbon fractions in 7-10 (A) and 3-5-t (B) crop rotations

Between the Yamb-N and the Sorgh of the gumming of by-products, a direct strong correlation was established (R = 0.70-0.75 ± 0.003; R2 = 0.49-0.66) irrespective of the rotational and crop rotation type (Fig. 2). On the unit of Emb.-N there are 0.02 carbon units of humicification of by-products in crop rotations with a long rotation, whereas in crop rotations with a short rotation of 0.003 Sorg units from the rubberization of by-products, which is 1.5 times more efficient than crop rotation with a long rotation.

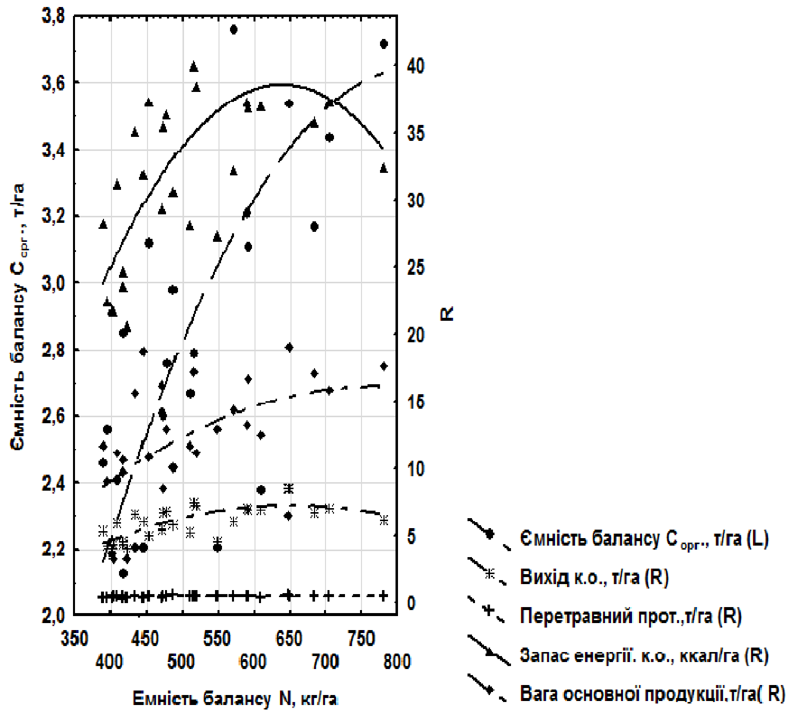
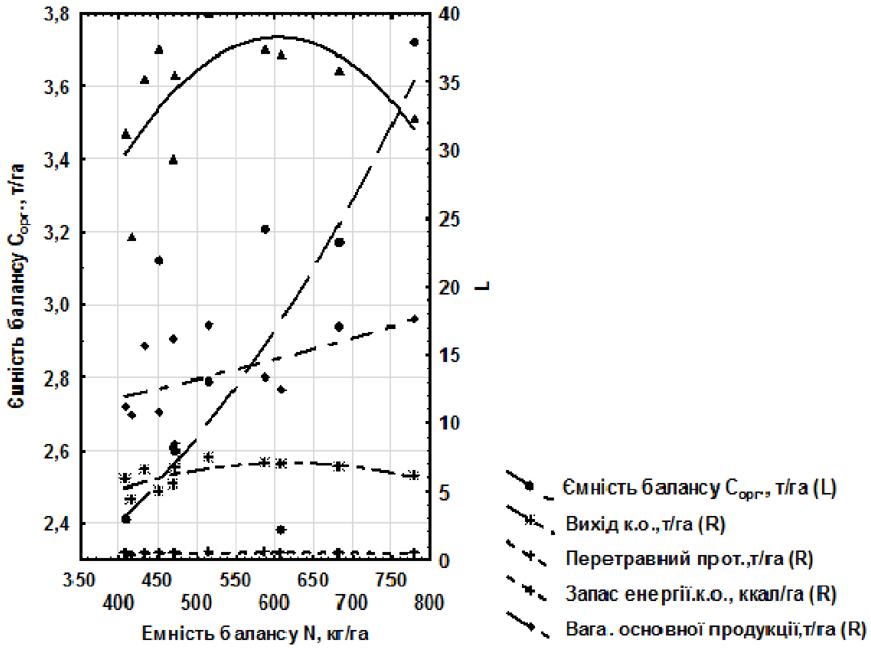


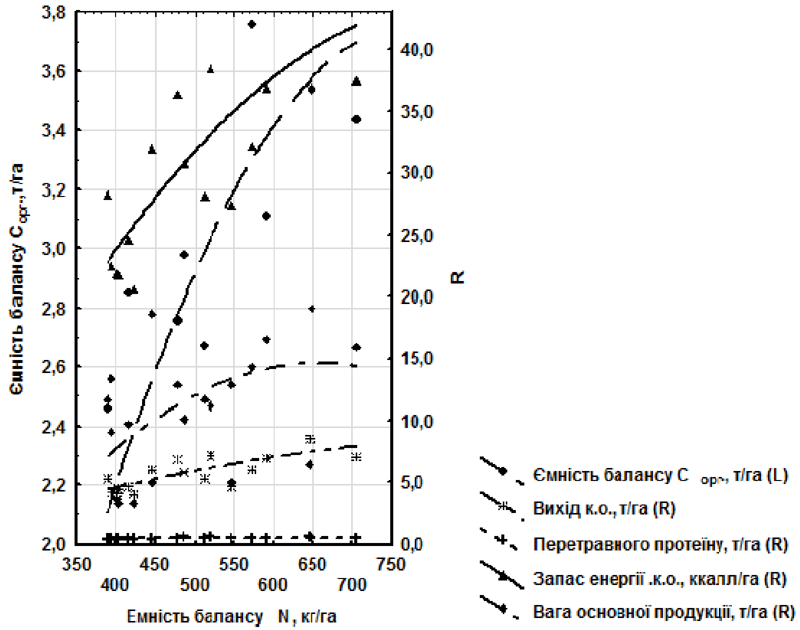
Fig. 3. Dependence of Emb.-N and Emb-Sorg with parameters of productivity and quality of the main products in unequivocal crop rotations (general model).

Between Emb.-N and Emb-Sorg, a direct correlation relationship was found at the level of direct strong correlation (R = 0.73-0.75 ± 0.003; R2 = 0.53-0.56) for crop rotation with long rotation and a short rotation, and the unit cost of Emb.-N is 0.003 units of expenditure of Amb.-Sorg in 10-way crop rotations and 0.005 units of Amb.-Sorg, which is 1.78 times more

In the general model of the dependence of the indicated parameters of nitrogen-carbon treatment, the relation was at the direct strong correlation level (R = 0.71 ± 0.003; R2 = 0.50), and on the unit Eimbus-N was 0.004 units of Emb.-Sorg. (Fig.3).



7-10 pounds (A)



3-5 pounds (B)

Emb. N: Emb-Sorg: y = 1,09 + 0,003 * x; r = 0.77;
Ammunition-N: cu, t / ha: y = 4,59 + 0,003 * x; r = 0.45;
Emb-N: Pr.prot., T / ha: y = 0.40 + 0.0002 * x; r = 0.41;
Em-b-N: Energetic: y = 28,4 + 0,011 * x; r = 0.35;
Emb-N: Weight. basic prop, t / ha: y = 5.83 + 0.015 * x; r = 0.56; 0.55;

Emb.-N: Emb-Sorg: y = 0,112 + 0,005 * x; r = 0.73;
Emb. N: cp, t / ha: y = -0,021 + 0,012 * x; r = 0.79;
Emb. N: Pert.prot., T / ha: y = 0.34 + 0.0004 * x; r = 0.65;
Emb.-N: Energ.k.o .: y = -1,08 + 0,065 * x; r = 0.81;
Emb-N: Weight of the bases. Prod, t / ha: y = -2.12 + 0.03 * x; r =

Fig. 4. Dependence of Emb.-N and Emb-Sorg with parameters of productivity and quality of basic products in 7-10-way (A) and 3-5-way crop rotations (B).

In turn, a direct strong correlation was found between the Yamb-Sorgh and the crop rotation productivity ($R = 0.69-0.71 \pm 0.002$; $R2 = 0.48-0.50$), and between Yamb-N and performance parameters crop rotation of the linkage was direct at the level of strong correlation: $R = 0.70-0.74 \pm 0.002$; $R2 = 0.49-0.55$. In crop rotations with a long rotation between the Emb.-N and the Emb-Sorge, the correlation was at the direct strong correlation level ($R = 0.75 \pm 0.003$; $R2 = 0.56$). Between the Yemb.-Sorgh and the productivity parameters, the connection weakened to a direct average level ($R = 0.56-0.59 \pm 0.003$; $R2 = 0.31-0.35$), while the unit Ymb.-Sorg was 0, 35 units of exit and 0.07 units of digestible protein (Fig. 4). In short-rotation crop rotation, the connection between Yemb.-N and Yemb.-Sorg increased to a direct strong correlation, both in crop rotations with long rotation, and between the Yemb.-Sorg and the parameters of productivity the connection increased to the level of direct strong correlation: $R = 0.76-0.83 \pm 0.003$; $R2 = 0.58-0.69$, and the unit of Emb.-Sorg accounted for 1.65 units of output. and 0,62 units of digestible protein, which is 4.7 and 8.9 times more efficient with respect to the production of 7-10-crop crop rotation. For crop rotation with a long rotation per unit Yemb.-Sorg accounted for 3.42 units of energy intensity of grain-protein units, whereas in 3-5-crop crop rotations per unit Ymb.-Sorg - 8.77 units of energy, which is 2.56 times more efficiently, and between the indicated indicators in the first case the correlation relationship was at the level of direct average correlation, in the second case the connection was at the level of direct correlation, which indicates a higher productivity of 3-5 crop rotation. In short-rotation crop rotations, the link between Yemb.-N and Yemb.-Sorg and the productivity, quality and energy value of the main products is simultaneously increased: $R = 0,59-0,79 \pm 0,003$; $R2 = 0.31-0.65$ for Emb.-N and R = 0.76-0.82ą0.003; $R2 = 0.58-0.66$ for Emb.-Sorg, whereas in synchronized crop rotations with a long rotation, the strengthening of bonds is weakened to an average level; the nitrogen turnover becomes determinative in the formation of the productivity of crop rotation (Fig. 4).

Conclusions

1. With the complete abandonment of by-products in 7-10-crop rotations, the Sorg equilibrium was positive, and the maximum productivity was the same as the highest balance values (1.32-2.54 t / ha) and the balance capacity (3.17-3.72 t / ha). In the 3-5-crop rotations, the Sorg equilibrium was less profitable (+ 0,56- + 0,87 t / ha), but the capacity of the balance Sorgh increased for the manifestation of maximum productivity to 4,01-4,12 t / ha.

2. Correlation between the capacity of the Sorg equilibrium and the productivity of crop rotation has been revealed, and with increasing productivity of crop rotation, both mineralization and Sorgh humification increase proportionally. The capacity of the balance in short rotation crop rotations in maximum values exceeds 4 t / ha, while keeping 7-10-cubic crop, the maximum value of the capacity of the balance does not reach 4 t / ha.

3. The Sorge to nitrogen ratio, irrespective of the type of crop rotation, is within optimal limits (20-30 to 1), which creates optimal conditions for the humification of by-products and the formation of humus, which confirm the balance calculations of nitrogen and Sorg.

4. In the general communication model, it was established that there is a direct correlation between Emb.-Sorg and Emb.-N, and the unit cost of Emb.-Sorg is 120 units of Emb.-N, which indicates a close connection between nitrogen and carbon traffic in agrocenoses of diversified crop rotation. In the long and short rotation crop rotations, the connection between the indicated indicators was also at the level of direct strong correlation relations, indicating the conjugation of the nitrogen-carbon flow regardless of the rotation of the crop rotation.

5. Short-rotation crop rotations simultaneously increase the connection between Yemb.-N and Yemb.-Sorg and the productivity, quality and energy value of the main products, whereas in crop rotations with a long rotation, the synchronization of bond strength weakens to the average, and the nitrogen turnover in agrocenoses crop rotation becomes determinants in the formation of their productivity.

Bibliography

1. *Bazilevich N.I., Titljanova A.A.* (2008). Bioticheskij krugovorot na pjati kontinentah: azot i zol'nye jelementy v prirodnyh nazemnyh jekosistemah. [Biotic cycle on five continents: nitrogen and ash elements in natural terrestrial ecosystems]. Novosibirsk: Izdv. SB RAS. 381 p. [in Russian].

2. *Golubyatnikov L.L., Mohov I.I., Yeliseyev A.V.* (2013). Cikl azota v zemnoj klimaticheskoj sisteme. [Nitrogen cycle in the terrestrial climatic system]. *Izvestiya RAS*. *Physics of the atmosphere and the ocean*., Cikl azota v zemnoj klimaticheskoj sisteme. Vol. 49, No. 3. P. 255-270. [in Russian].

3. *Moiseev N.N., Aleksandrov V.V., Tarko A.M.* (1985). Chelovek i biosfera. Opyt sistemnogo analiza i jeksperimenty s modeljami. [Man and the biosphere. Experience in system analysis and experiment with models]. Moskva: Nauka,. 272 p. [in Russian].

4. *Thornton P.E., Doney S.C., Lindsay K. et al*. (2009). Carbonnitrogen interactions regulate the climate-carbon cycle feedbacks: results from an atmospheric general circulation model. *Biogeosciences.* V. 6. P. 2099-2120.

5. *Vitousek P.M., Howarth R.W.* (1991). Nitrogen limitation on land and in the sea: How can it occur? *Biogeochemistry*. V. 13. P. 87-115.

6. *Krapivin V.F., Svirzev Yu.M., Tarko A.M*. (1982). Matematicheskoe modelirovanie global'nyh biosfernyh processov. [Mathematical modeling of global biosphere processes]. Moskva: Nauka. 272 p. [in Russian].

7. *Friedlingstein P., Cox P., Betts R.A*. et al (2006). Climate_carbon cycle feedback analysis: Results from the C4MIP model intercomparison. *J. Climate*. V 19. No. 22. P. 3337-3353.

8. *Canadell J.G., Pataki D.E., Gifford R.* et al. (Canadell J.G., Pataki D.E., Pitelka L. Eds.) (2007). Saturation of theterrestrial carbon sink. Terrestrial ecosystems in a changing world. The IGBP Series. V. XXIV. N.Y .: Springer_Verlag. 59-73.

9. *Sabine C.L., Heimann M., Artaxo P*. et al. (Field C.B., Raupach M.R. Eds.) (2004). Current statusand trends in global carbon cycle. SCOPE 62: The global carbon cycle. London: Island Press. P. 17-44.

10. *Kapshtyk M.V., Demydenco O.V*. (2014). The ways to ecologically balanced development of agro ecosystems in the Forest-steppe zone of Ukraine. *International Journal of Agricultural Research and Review:* ISSN-2360-7971: Vol. 2 (8): P. 092-098, August.

11. *Denman K.L., Brasseur G., Chidthaisong A*. et al. (Solomon S., Qin D., Manning M. et al. Eds.). (2007). Couplings between changes in the climate system and bio_geochemistry. Climate Change 2007: The Physical Science Basis. Cambridge: Cambridge Univ. Press. P. 499-588.

12. *Chimitdorzhieva E.O*. (2011). Zapasy ugleroda v chernozjomah i kashtanovyh pochvah Zabajkal'ja i jemisija SO_2. [Carbon stocks in chernozems and chestnut soils Transbaikalia and the emission of CO_2]. Abstract diss. Cand. biol. sciences - Ulan-Ude. 21 p. [in Russian].

13. *Cox P.M., Betts R.A., Jones C.D.* et al (Pearce R. Ed.). (2001). Modeling the vege_tation and the carbon cycle as interactive elements of the climate system. Meteorology at the millennium. N.Y.: Academic Press. P. 259-279.

14. *Blagodatsky S.A., Larionova A.A., Evdokimov I.V*. (1992). Dejstvie mineral'nyh soedinenij azota na intensivnost' dyhanija i jeffektivnost' rosta mikroorganizmov v pochve. Pochvovedenie. [Effect of mineral compounds of nitrogen on the intensity of respiration and the efficiency of growth of microorganisms in soil]. Pochvovedenie. No. 9. P. 88-96. [in Russian].

15. *Zaehle S. Dalmonech D.* (2011). Carbon_nitrogen interactions on global global scales: current understanding in the modeling climate biosphere feedbacks. *Curr. Opin Environ* Sustain. V. 3. P. 311-320.