UDC 57.087:338.312+630*228:631.311.8-005.25:631.582(477.8)

Parameters of productivity and structure of biomass different crop rotations of Forest-Steppe of Ukraine

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The purpose. To develop methodology of agroecological assessment of productivity of different grain-tilling crop rotations on the basis of determination of normative parameters of productivity and structure of general biomass at use of collateral products as organic fertilizers in conditions of contemporary climatic system of Forest-Steppe of Ukraine. **Methods.** Field, statistical, laboratory. **Results.** Productivity of 7 – 10-field crop rotations increases proportionally to amount of the entered fertilizers and saturation capacity of crop rotation with cereal crops in structure of which saturation capacity with corn grows, and in group of forage crops — with perennial grasses up to 20%. Productivity of 3 – 5-field crop rotations depend on saturation of crop rotations by cereal crops up to 60%, where yield of f.u. makes more than 6 t/hectare. At reduction of rotation to 3 – 4 years and saturation of crop rotations by corn up to 30 – 40% the yield of f.u. increases up to 7,02 – 7,22 t/hectare. In 7 – 10-field crop rotations the high yield of unmerchantable produce has made 18,2 – 18,4 t / hectare, and collateral products with crop residues — 12,1 – 15,1 t / hectare. Yield of general biomass is proportional to productivity and depends on the share of roots, attaining 18,2 – 18,4 t / hectare. **Conclusions.** The content of nitrogen in general biomass of 7 – 10-field crop rotations increased at saturation of crop rotations by pease, soya bean and perennial grasses, and gained 290 – 399 kg/hectare. Productivity of crop rotations increased at ratio of nitrogen in basic and not-commodity parts of crop up to 1:1. That is connected with growth of the content of nitrogen in general biomass up to the maximum values. In 3 – 5-field crop rotations the maximum content of nitrogen in general biomass has made 315 – 365 kg / hectare.

Key words: *different crop rotations, over-all biomass, content of nitrogen in biomass, productivity, feed units, grain-protein of unit.*

https://doi.org/10.31073/agrovisnyk201805-09

The basis of the design of any crop rotation is, above all, biological restrictions, the essence of which lies in the aftermath of the predecessor [2-6]. The application of crop rotation should prevent the decline of soil fertility, and, if possible, ensure its growth, which will increase the yield, which is formed due to the implementation of the potential fertility of soils due to its effective form, [7-12]. The search for new agroecologically safe concepts of sustainable land use, based on which crop rotation, is an actual task of the present, the successful solution of which depends on the complexity of methodological approaches to the agroecological assessment of the efficiency of crop rotation. Natural indices are the main criteria for evaluating the effectiveness of crop rotation [13]. In recent years, attempts have been made to use energy analysis of crop rotation, as well as various agro-ecological assessment methods, depending on the effect of a particular environmental factor [14]. Separate methodological approaches do not represent a single

metrological complex, which would reflect an integrated assessment of the efficiency of crop rotation [15]. The development of the methodology of agroecological assessment of the productivity of diversified grain-seed crop rotation is based on the establishment of normative parameters of the structure of total phytomass, models of nitrogen-carbon and CO 2 circulation with the use of by-products as organic fertilizers under the conditions of the forest-steppe of Ukraine.

The aim of the study. To establish normative parameters of typification of phytomass structure and nitrogen content in it 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 analysis of productivity parameters, structure of total phytomass.

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. 10-crop rotation crop rotations in 12 five-crop crop rotation, two four-wheeled, one semipillar and six trypilnym crop rotations were reconstructed. The crop rotation is shown in tables 1.3. 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 cultivation in crop rotation-differentiated. Exit structure of phytomass was determined by F. I. Levine [15], supply of nitrogen in the structure of phytomass for AV. Ivoilov [16]. Summarization of materials and calculations of the results of research were carried out using the "Meded Dispersion Analysis" [17] and the program "STATISTICA" nonparametric statistics.

Research results. The first stage in the development of the methodology of agroecological assessment of the productivity of uneven grains and seed crops is the typing of the parameters of productivity and the structure of the total phytomass. In the 7-10-crop rotations, the typical interval of variation in productivity was 5.59-6.83 t kO. from 1 ha The most productive variants of crop rotation No. 8, 2, 13, where leguminous and forage crops ranged from 10% to 30%, and the least productive variants of crop rotation №18 (control without fertilizers), 5 and 16. The lowest productivity of crop rotation at the exit of k.o. .and the digestible protein (Kr.p-t.) per 1 ha was in control without fertilizing. On the same type of crop rotation (option number 9), where the N560 P580 K580 is introduced, the productivity of the crop rotation at the exit of the k.o. grew by 152%, and at the exit pr.p-t. - by 151%. The coefficients of variation of productivity indices of 7-10-crop rotation varies within 12.1-14.8%, which indicates the stability of the productivity of crop rotation in time (Table 1). The productivity of 7-10 crop rotations depended directly on the amount of mineral fertilizers applied per ha of crop rotation. The cywaves were grouped by the NPK into 3 groups: 165-180 kg. dp, 185-190 kg.д.r. and 190-205 kg.ha dp .. The fraction of nitrogen in the amount of NPK was 55-60 kg d.r., 60-63 kg d.r. and 65-68 kg dp per 1 hectare of crop rotation according to crop rotation grouping.

1. Productivity of 7-10 grains of cereal-crop rotation in a multi-year stationary experimentfor 2005-2015

№ вар	Var Crop rotation structure introduced	Added NPK kg dp on 1 ha	Productivity at output (t / ha):	
			fodder units (cf.)	feed proteins-new units (pc)
18*	50% grain; 10% -above; 20% -think; 20% fodder: no fertilizers - 4.43 3.97	-	4,43	3,97
5	50% -green; 20% -think; 30% fodder. 204 5.51 4.95	204	5,51	4,95
17	40% - cereals; 20% - beans; 30% -technical (20% - sunflower, 20% - beet); 10% - forage 165 5.87 5.48	165	5,87	5,48
12	40% - cereals; 10% sugar beets; 30% fodder; 10% -good 168 6.08 5.69	168	6,08	5,69
7	50% green; 10% -above; 30% - Sprouts (10% - soybeans, 20% - beets); 10% fodder 196 6.61 5.86	196	6,61	5,86
14	70% - grain; 10% - beans; 20% -technical (10% -soy, 20% - beets). 185 6.67 5.99	185	6,67	5,99
9	50% -grains; 10% -above; 20% -think; 20% fodder: With fertilizers 175 6.73 6.02	175	6,73	6,02
8	50% grains, 30% (soy-10%, sunflower-10%, sugar beet-10%); 20% fodder 189 7.03 6.42	189	7,03	6,42
2*	50% grains; 20% sugar beets; 20% big; 10% - fodder. 185 7.47 6.54	185	7,47	6,54
16**	56% -grains (28% -experienced wheat); 43% technical (14% sugar beet, 14% sunflower, 14% sunflower), 14%, one-year grass, 177 5.03 5.07	177	5,03	5,07
13**	72% -grains (44% corn); 14% sugar beets; 14% perennial grasses 185 6 , 93 5.82	185	6 ,93	5,82
$HIP_{0.05}$		-	0,62	0,56

Note: * 10 crop rotations (18-2); ** 7th crop rotation (16-13).

2. Withdrawal by-products * and nitrogen content in the biomass component of the total cultivated grain-7-10-ti rotation of the fields for 2005-2015.

Code crop rotation	Weight, t / ha:					Nitrogen content (kg / ha) in:			
	the main one products	collateral + squash remains	the roots	non-commodity products	together	the main one products	by-products	the roots	phytomass together
Ten-year crop rotations									
18	10,6	6,7	5,7	12,4	23,0	102	47,0	63,0	214
5	16,2	8,7	1,3	14,7	30,9	122	47,0	58,0	227
17	11,2	9,1	4,0	12,7	23,9	97,0	54,0	36,0	186
12	17,2	13,0	4,8	17,8	35,0	120	73,0	57,2	250
7	15,7	9,6	4,2	13,9	29,6	95,0	53,0	45,0	192
14	8,56	11,6	4,7	16,3	24,9	104	69,0	42,0	216
9	17,0	15,1	5,1	18,2	35,0	172	52,0	96,0	319
8	13,3	12,0	6,8	18,8	32,1	142	84,0	56,0	290
2	17,6	9,2	9,2	18,4	36,0	189	65,0	145	399
Semiropic crop rotation									
16	10,8	8,7	4,9	13,5	24,3	120	41	41	202
13	12,5	12,8	4,7	17,5	30,0	167	80	49	296
Statistical evaluation of parameters									
Mean	13,7	13,7	5,04	15,8	29,6	130	60,5	62,6	253
C.v,%	23,0	23,4	38,2	15,5	16,0	25,3	24,0	50,8	25,9
$HIP_{0.05}$	2,11	2,11	1,27	1,63	3,21	21,8	9,61	21,1	43,6

The growth of productivity of crop rotation occurred up to the level of making NPK - 190 kg dp, and with increase - up to 200 kg dp productivity at the exit k.o. and Kr.p-t. declined. Limit of introduction of nitrogen of mineral fertilizers: 62-65 kg.д.r. per 1 hectare.

By-products were used as organic fertilizers, making an average of 13 t / ha, and an increase in the productivity of 7-10-crop crop rotation depended on the amount of imported by-products: the output of k.o. more than 7 t / ha was obtained when the by-product was introduced more than 13 t / ha. The output of the main products varied in the range of 1.6-15.8 t / ha for the value of the coefficient of variation of 23%. The output of the main products at the border of the upper typical value provided options for crop rotation: No. 9, 12, 2 and 5, and below the limit: No. 18, 7, 8, 14, 17. Output of by-products varied in the typical range of 8.94 - 12, 2 t / ha. By the limit of the upper typical value, the yield of by-products was on variants of crop rotation No. 9, 8, 2 and 5, while the options for crop rotation No. 18, 5, and 16 had a yield of by-product less than 8.94 tons / ha. The yield of root mass varied in the typical range from 4.80 to 6.31 t / ha. In the crop rotations No. 8, 12, the root mass yield exceeded the upper typical value (6.8 - 9.2 t / ha), while in variants No. 7, 14, 17, 13 the yield of the root mass declined beyond the typical minimal value.

The total unprocessed share of the crop, including the root mass, varied within the range of 14.1-17.4 t / ha. In the crop rotations No. 9, 8, 12, 2, 13, the weight of the total non-food products exceeded the upper standard limit, and in crop rotations No. 18, 7, 17, 16 the weight of non-commodity products was outside the lower typical value. The coefficient of variation in the yield of total by-products was 23%, the root mass - 38.2%, non-food products - 15.5%. The yield of total phytomass varied in the typical range of values: 26.4-32.8 t / ha with a coefficient of variation of 16%, indicating the stability of crop rotation as a result of the formation of productivity, and the output of by-products. The average yield of structured phytomass is shown in Table 2.

Estimation of nitrogen supply in the components of total phytomass showed that in the main products the interval of nitrogen reserve was 108-152 kg / ha, with the coefficient of variation - 25.3%. In the crop rotations Nos. 9, 12, 13 (where leguminous and perennial grasses> 30%), the nitrogen supply exceeded the upper typical value, and in crop rotations No. 18, 17, 7 the stock was less than 108 kg / ha (crop rotation where the leguminous and annual herbs accounted for up to 20%). Depending on the structure of seven to ten crop rotations, the structure of phytomass changes and productivity at the exit of the k.o. and feed protein units per 1 hectare of crop rotation. The cywaves were divided into 3 groups: high performance (№ 9,2,12); with average productivity (No. 17,13,8,7,5); with low productivity (14,18,16,17). In crop rotation with low productivity, the ratio of the weight of the main products to the weight of by-products and roots was: 1: 0.54: 0.30; average performance: 1: 0.83: 0.43; Crop rotation with high productivity: 1: 1.23: 0.40. Ranking of crop rotation after the output of basic products showed that the highest productivity was then when the ratio of the structure of phytomass: 1: 0.72: 0.37; with an average performance: 1: 0.76: 0.31; with low performance: 1: 0.87: 0.43.

The stock of nitrogen in the by-products varied in the typical range: 50.8-70.0 kg / ha, with a coefficient of variation of 24%. In crop rotations with saturated peas, soybean and annual grasses (No. 8, 2, 13), the nitrogen supply exceeded the upper standard value, and in variants of crop rotation No. 18, 5, 16 the nitrogen supply decreased for a minimal typical value. The stock of nitrogen in the roots averaged 62.6 kg / ha, and the interval - 41.7-84.0 t / ha with a coefficient of variation of about 50%. In variants No. 9,12, the stock of nitrogen in the roots (annual and perennial grasses) exceeded the upper typical values (96 and 145 kg / ha), and in the crop rotation number 17 (annual grasses and peas) the nitrogen supply in the roots was less than 41.7 kg / ha. Nitrogen stock in the total phytomass of 7-10-crop rotation varied in the range of values 209-296 kg / ha with a coefficient of variation of 25.9%. In the crop rotations No. 8, 12, 13, the nitrogen supply exceeded the upper typical value (> 296 kg / ha), and in crop rotations No. 7, 17, 16 it was less than 209 kg / ha, due to the saturation of multi-year crop rotation herbs (Table 2).

3. Productivity of 3-5 tons of grain crop rotation for 2005-2015.

№	Crop rotation structure	Added NPK kg d.r./ha	Productivity (t / ha):	
			fodder units (cf.)	Fat-Protein Units (pc)
4*	60% -grains (40% -years); 20% rape; 20% - high	165	4,31	4,56
1	60% -green (40% wheat isozym); 20% sugar beets; 20% perennial herbs	165	4,62	4,76
11	60% - grain (40% wheat isozym); 20% rape; 20% perennial herbs	165	4,64	4,87
11a	40% -grains; 40% sugar beets and soy beans; 20% -good	188	5,26	5,23
4a	60% -green (40% -years of the eartag); 20% sugar beet; 20% peas	188	5,32	4,86
6	40% - cereals; 40% -technical (soy-20%; rape-20%); 20% -good	165	5,78	5,94
6a	40% grains; 20% big; 20% sugar beets; 20% - maize for silage	185	5,98	5,34
15	60% grains; 20% sugar beets; 20% - one-year grass.	165	6,06	5,73
1a	60% grains; 20% big; 20% sugar beets	165	6,82	6,01
10a	60% grains; 20% sugar beets; 20% perennial herbs	188	6,94	6,12
15a	60% grains; 20% sugar beet; 20% perennial herbs	188	7,02	6,06
10*	60% - cereals (40% corn); 20% - peas; 20% - fodder.	165	7,22	6,66
3**	50% -green (25% corn); 25% - sugar beets; 25% - forage	190	8,53	7,11
13a***	66% -grains (33% - barley); 34% - soy	188	4,00	4,21
3a	66% -grains (33% - barley); 34% - peas	133	4,11	4,21
3б	66% -grains (33% - spring wheat); 34% - soy	188	4,43	4,82
16в***	66% corn; 34% soy	188	8,54	7,52

Note: * 5 crop rotations (4-10); ** 4 free crop rotation (3); 3-way crop rotation (13a-16v)

In short-rotation crop rotation (3-5-pile) productivity at the exit of the k. O. and Kr.p-so. per hectare of crop rotation varied in a narrower range compared with 7-10-crop rotations. At the same time, the coefficient of variation for short-term crop rotation increased by 1.68 times and amounted to 25.1%.

In the crop rotations No. 1a, 10, 10a, 15a, 3, 16b the output of the c. and Kr.p-so.went beyond the limits of typical interval values (5,06-6,74), and in the crop rotations No. 1, 4, 11 (5-plow) 3a, 3b, 13a (3-ply), the output to the op. and Kr.p-so. declined beyond the standard minimum value. Content of Kr.p-ts.in short-rotation crop rotations depended on the content of grain and leguminous crops. Exceeding the content of the upper limit of the standard value (0,53 t / ha) was consistent with the laws of the exit of the c. and saturation with cereals and legumes - crop rotations number 6, 10, 10a, 15, 3, 16b. For the lower limit of the standard value (0.49 t / ha), the contents of the k.o. and Kr.p-so. Crop rotations No. 1, 4, 4a, 6a, 3a, 13a came out.

The productivity of short-term crop rotation depended on the amount of fertilizers (Table 3). In the first group of crop rotation (No. 4, 1, 11a, 6, 15, 10), 165 kg of NPK (55 kg N) was introduced, and in the second group of crop rotations (No. 3b, 4a, 11a, 10a, 15a, 16b) 188 kg dp NPK (No. 62-63 kg N). Maximum productivity in the first group of crop rotation was obtained in crop rotation №10 - 7.22 t / ha. per 1 hectare and 0.61 t / ha Krp-so. Productivity increased by 1,67 times compared with crop rotation No. 4. On the raised backgrounds of mineral fertilizers, crop rotation increased to 19.1 tonnes of cu. from 1 hectare, which is 2.9 times higher in comparison with crop rotation №3b. When adding mineral fertilizers 190 kg d.r. per 1 hectare output at k.o. has increased by 2-3%, which gives grounds to determine that the optimal dose of mineral fertilizers is 188-190 kg d.r. per 1 hectare with saturation of crop rotation with corn and sugar beet up to 20%. Dose of mineral fertilizers 165 kg d.r. 1 hectare of crop rotation is optimal for crop rotation with winter and spring wheat and corn. The introduction of mineral fertilizers is less than 135 kg d.r. 1 ha of crop rotation is ineffective.

The yield of by-products in short-rotation crop rotations varied in the range of 10,2-13,4 t / ha with a coefficient of variation of 27%, which is somewhat higher than in 7-10-crop rotations. The yield of by-products in crop rotations Nos. 1a, 3, 3a, 3b, 13a exceeded the maximum typical value (13.4 tons / ha), and crop rotations No. 1, 4, 6a, 11, 15 at the output of the by-products exceeded the minimum typical value . The higher the yield of by-products, which was used as organic fertilizer, the higher the productivity of short-term crop rotation: for yield 6,82-8,54 tons. from 1 hectare, the saturation of by-products should be 15-17 t / ha.

The yield of root mass in 3-5-crop rotational crops had a typical interval of change of 4.37-6.65 t / ha, with a coefficient of variation of 40.7% against crop rotation with a long rotation of 38.2%. In the crop rotations No. 6, 15, 15a, 3, and 16b, the yield of root mass exceeded the maximum typical value, whereas in crop rotations Nos. 1a, 6a, 3a, and 3b the stock of root mass was less than 4.37 t / ha. In general, the weight of non-food products in 3-5-crop rotation crop with typical interval values (13.3-17.5 t / ha) corresponded to 7-10-crop rotation. In the crop rotations Nos. 10, 15, 15a, 3, and 16b, the output of the unpopulated particle was higher than the maximum typical value, and in crop rotations Nos. 6a, 3a, and 3b decreased for the minimum typical values. The weight of total phytomass in short-rotation crop rotations had a typical interval of 24.8-30.4 t / ha with a coefficient of variation of 26.3%, which is higher than the values of Кв in the 7-10-crop rotations in 1.64 times. Shorter crop rotation where the yield of total phytomass exceeds the maximum typical value is directly correlated with the articles of productivity, the output of by-products and the root mass, and these are options number 6a, 10a, 15 and 15a. All 3-crop rotations had a total yield of phytomass less than the minimum typical value. The estimate of 3-5 tons of crop rotation at the output of the main products divided them into 3 groups: with high productivity (No. 15,15a, 10a, 6a, 3) where the ratio of the components of total phytomass was 1: 0.65: 0.41; with an average productivity of crop rotation (No. 4,1,6,10,11a, 4a, 11,1a) the ratio was 1: 0,93: 0,49; with a low display of productivity of crop rotation (№ 13а, 3б, 3а, 16б) the ratio was 1: 5,7: 1,16.

4. Output of by-products and nitrogen content in the components of total phytomass of grain-sowing 3-5-crop crop rotation for 2005-2015.

Code crop rotation	Weight kg / ha					Nitrogen content (kg / ha) in:			
	the main one products	indirect + corpulent remains	The roots	non-commodity products	Together Phytomass	the main one products	by-products	The roots	Phytomass together
Five crop rotations									
4	9,1	7,80	5,61	13,4	22,5	79,0	52,0	46,0	177
1	9,7	8,00	5,80	13,8	23,5	89,0	54,0	48,0	191
11	12,9	7,61	4,40	15,0	27,9	152	48,0	65,0	266
11a	11,7	10,6	4,40	15,0	26,7	110	81,0	57,0	248
4a	11,7	11,8	3,00	13,6	25,3	82,0	48,0	26,0	161
6	10,0	10,8	9,20	16,8	26,8	102	70,2	55,0	227
6a	18,7	9,20	3,80	13,0	31,7	100	55,0	46,0	200
15	14,3	7,61	10,2	17,8	32,1	78,0	51,0	81,0	209
1a	12,9	13,4	2,80	16,2	29,1	107	72,0	30,1	230
10a	16,6	11,6	4,80	16,4	33,0	173	89,0	44,0	306
15a	15,9	12,4	7,60	21,2	37,1	199	90,0	76,0	365
10	11,2	12,8	5,80	18,6	29,8	121	79,0	68,0	268
4-way crop rotation									
3	19,1	14,0	6,75	23,0	42,1	190	68,0	69,0	328
3 miles of crop rotation									
13a	3,24	16,7	5,3	10,3	13,5	80,0	26,0	51,0	174
3а	3,58	17,0	3,0	8,67	12,3	76,0	36,0	20,0	140
3б	3,28	17,0	3,0	8,67	12,0	72,0	35,0	32,0	139
16б	6,43	13,0	8,0	21,0	27,1	127	106,0	92,0	315
Statistical evaluation of parameters									
C.v,%	36,8	27,0	40,7	26,8	26,3	36,1	35,2	37,7	29,3
$НІР_{0.05}$	1,74	1,63	1,14	2,13	2,81	21,1	11,3	10,3	34,8

Ranking of 3-5 crop rotations at the exit of the c.o. divided them into 3 groups: with the exit k.o. more than 7 t / ha (№ 15a, 10,3,16b) where the ratio of the components of phytomass was 1: 1,17: 0,65; with exit k.o. more than 5-6 t / ha (No. 11a, 4a, 6,6a, 15,1a, 10a) ratio was 1: 0.82: 0.43; with exit k.o. less than 5 t / ha (No. 13a, 3a, 4,3b, 1,11), the ratio of phytomass components varied to 1: 2,89: 0.83.

The average yield of by-products and nitrogen content in the total phytomass of grain-sowing 3-5-crop crop rotation for 2005-2015 is shown in Table 4. The nitrogen supply in the main products of 3-5 crop rotations varied in the typical range of values of 93- 135 kg / ha, which is much narrower (in the upper typical value) compared with 7-10-crop rotations. The coefficient of variation was 36.1%, which is 1.43 times higher than in crop rotations with long rotation, and the value of the variation index exceeds the statistical limit of stability (30%). Statistically higher nitrogen supply in main products was in crop rotations Nos. 10a, 11, 15a, 3, and below the minimum typical value in crop rotations No.4, 4a, 15, 3a, 3b, 13a. The content of nitrogen in the by-products varied in the range of typical values of 51.1-73.7 kg / ha, which is practically the same with crop rotations with a long rotation. The coefficient of variation was 35.2%, which is 1.47 times higher compared to 7-10-crop rotations. The stock of nitrogen in the root mass was narrowed (above the typical value) of 43-63.6 kg / ha, but the coefficient of variation was 57.7%, which is lower in 1.35 times compared with 7-10-crop rotations. Statistically higher nitrogen supply in by-products was in crop rotations No. 10, 10a, 11, 15a, 16b, and in the root mass No. 6a, 11, 15, 15a, 3, and 16b. These variants of crop rotation were highly saturated with corn. The stock of nitrogen in the total phytomass of short rotation crop rotation varied in the typical range of values: 197-266 kg / ha, with a variation coefficient of 29.3%, which is higher compared to 7-10-crop crop rotations. The highest nitrogen content in the phytomass was crop rotation No. 3, 10, 10a, 15a, and crop rotation Nos. 1, 4, 4a, 3a, 3b, 13a with the nitrogen reserve went beyond the typical range of values.

The dependence of the productivity of uneven crop rotation on the structure of the above-ground phyto mass and the nitrogen supply in it is shown in Figure 1. Calculations showed that the yield of total phytomass depended on the weight of the main products (R = + 0.83 ± 0.03), the weight of the by-product and the weight of the roots (R = + 0.80-0.82 ± 0.03), and between the exit to the k. from 1 ha of crop rotation and the total weight of phytomass, the ratio was at the level of the mean direct correlation (R = 0.60-0.62 ± 0.03).

Between the stock of nitrogen in the main products, the output of by-products and the total weight of phytomass, direct correlation was established (R = 0.72-0.77 ± 0.03).

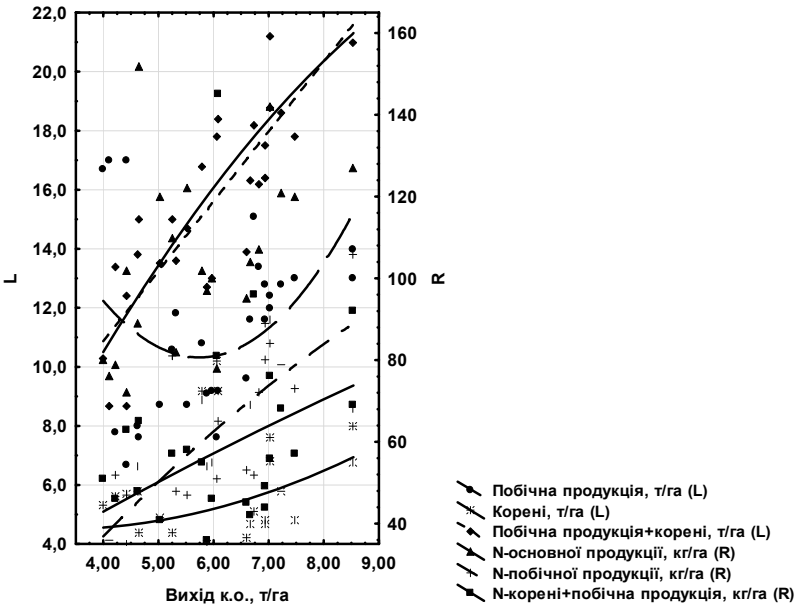

Fig. 1.Dependence of productivity of 3-10-crop crop rotation on the structure of above-ground phytomass and nitrogen in it (general model).

Between the stock of nitrogen of total phytomass and the stock of nitrogen in the main products, the connection at the level of direct strong correlation (R = + 0.83-0.85 ± 0.03) was established, and with the content of nitrogen in the roots, the level of the correlation connection was weakened to values: R = + 0.71-0.77 ±

Conclusions

1. The productivity of 7-10-crop crop increases in proportion to the amount of mineral fertilizers introduced and the saturation of crop rotation with grain crops, which increase the saturation of corn, and in the group of forage crops - perennial herbs up to 20%. Similarly, the productivity of crop rotation increases with the release of feed-protein units, the level of which is associated with the saturation of corn, soybean and perennial herbs. Maximum productivity is achieved in crop rotations with grain saturation up to 50-72% with the output of c. 6.61-7.49 t / ha, and feed protein units - 5.89-6.54 t / ha.

2. Productivity of 3-5-crop crop rotation depended on the saturation of crop rotation with grain crops to 60%, where the output of c. is more than 6,0 t / ha, and with the reduction of rotation to 4-3 years and the saturation of crop rotation with maize up to 30-40% output to. grows to 7.02-7.22 t / ha. at the maximum saturation of corn output to. o. grows to 8.54 t / ha. the maximum yield of feed protein units was in crop rotations with a maximum saturation of maize and soya - 6,42-6,54 t / ha.

3. The nitrogen content in the total phytomass of 7-10-cubic crop increased with saturation of crop rotation with peas, soybean and perennial herbs and reached 290-399 kg / ha. The productivity of the crop rotation increased with the ratio of nitrogen content in the main and non-commodity yield fraction to 1 to 1, which is due to the increase in the nitrogen content in the total phytomass to the maximum values. In 3-5-crop rotation, the maximum nitrogen content in total phytomass was 315-365 kg / ha. Productivity of short rotation crop rotation was the highest when the ratio of the nitrogen of the main product to the non-commodity tends to favor the nitrogen of the main products (1.3-1.4 to 1), and the maximum nitrogen supply in the total phytomass reaches 315-365 kg / ha.

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