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NITROGEN BALANCE IN FOUR-FIELD CROP ROTATION UNDER DIFFERENT UTILISATION OF BY-PRODUCTS IN ENVIRONMENT OF FOREST-STEPPE OF UKRAINE

The article presents the results of studies on the effect of saturating four-field crop rotations with grain (50% to 75%) and row (25% to 50%) crops against the background of by-products application as an organic fertilizer on nitrogen balance intensity. It was established that provided engaging by-products to fertilizing practice, the virtually non-deficit balance of nitrogen in crop rotations is establishing, with share of legumes (red clover, pea for grain) being not less than 25% and row crops not more than 25%.

***Keywords**: nitrogen balance; organic and mineral fertilizers; crop rotation; grain crops; row crops; by-products*

Introduction. The current fertilizing practices in crop rotations leads to increased rates of nitrogen fertilizers and decreased use less organic ones [1] This leads to disruption of ecological sustainability of agro-ecosystems and cause irreversible damage to human health, especially in rural areas. To prevent unreasonable application of nitrogen its balance must be considered in rotation.

In terms of domestic farming the nitrogen balance is very intense [2] that is determined (according to the I.G. Zakharchenko [3])(apart from uptaking by crop) by losses of significant amounts of nitrogen at the denitrification process. Some portion of nitrogen is being fixed by soil and minerals leaving the process of its circulation.

The main source of nutrients expenditure is their removal together with harvest. According to scientific data [4] at high yields the removal of nitrogen can be reimbursed by fertilizer by 45-50% only.

The use of organic-mineral fertilizing practice at the physiologically-based standards improves nitrogen balance in the soil [5, 6].

The goal of the research was to investigate the impact of saturating four-field crop rotation with grain and row crops against the background of different ways of utilizing crop by-products on nitrogen balance.

Materials and methods. Research was carried out as a stationary experiment at Khmelnytsky SAEBS of the Institute for fodder and agriculture NAAS of Ukraine in the area of sufficient moisture in north-western part of the Right-Bank Forest-Steppe during 2008-2011.

Soil in research fields was podzolic chernozem characterized by the following agrochemical characteristics of topsoil: salt extraction pH 5.6-6.2; amount of absorbed alkali of 37.9-42.2 meq./100 g of soil; humus content (by Tiurin) of 3.50%; content of mineral nitrogen of 65-83 mg/kg of soil; P_2O_5 and K_2O (by Chirikov) 163-178 and 55-73 mg/kg soil, respectively.

Crop rotation were located at four fields; observation time duration 4 years. Sown plot area 175 m^2, accounting 100 m^2; four-time replication. When calculating nitrogen balance, natural sources of replenishment, non-productive losses of fertilizer (by Tatarik), losses with lysimetric water were also considered [5].

The scheme of crop rotation was as following:

1. Red clover - winter wheat - sugar beet - barley with clover; 2. Pea for grain - winter wheat - sugar beet - spring wheat; 3. Maize with soybean for silage - winter wheat - sugar beet, spring wheat; 4. Buckwheat - winter wheat - sugar beet - spring wheat; 5. Maize with soybean for silage - winter wheat - sugar beet - buckwheat; 6. Spring barley - winter wheat - sugar beet - buckwheat; 7. Pea for grain - winter wheat - sugar beet - buckwheat; 8. Pea for grain - winter wheat - sugar beet - spring barley.

In the experiment we applied organic and mineral fertilizing as follows: 30 tons of manure + $N_{90}P_{80}K_{90}$ for sugar beets; $N_{45}P_{20}K_{30}$ for winter wheat; $N_{45}P_{20}K_{20}$ for barley, spring wheat and buckwheat; all predecessors of winter wheat were grown without fertilizing. Total amount of fertilizers per 1 ha of crop rotation area made up 7.5 tons of manure + $N_{45}P_{30}K_{35}$.

Results. Studies showed that in the observed rotation the deficit balance of nitrogen took place of 53.51 and 42.79 kg/ha, that was due to the lack of legumes and consequently biological nitrogen in soil. The most intense nitrogen balance was observed in crop rotations, saturated with corn+soybean (up to 25%), where it was combined with spring wheat and buckwheat (76.68 and 63.09 kg/ha), due to significant removal of nitrogen out of soil by green mass of corn. In crop rotation saturated with red clover rotation (up to 25%) much less lack of nitrogen was observed (35.65 kg/ha) because of nitrogen content replenishment through its biological fixation by this legume crop (Table 1).

Table 1

Balance of nitrogen in short-crop rotations with different saturation with grain and row crops (second rotation) (average for 2008-2011)

Saturation of crop rotation, %		Article of balance, kg/ha											Balance of nitrogen, kg	Balance intensity, %
		Expenditure				Supply								
Grain crops	Row crops	Total removal with harvest	With lysimetric water	Gaseous losses	Total	With fertilizers	Including organic	With mineral fertilizers	With seeds	With precipitation	Nitrogen fixation from the air	Total	Per 1 ha of area/year	
50	25	148.95	14	12	174.95	80	35	45	2.3	13	44	139.3	-35.65	80
75	25	158.95	14	12	184.95	80	35	45	6.3	13	16	115.3	-69.65	62
50	50	155.88	14	12	181.88	80	35	45	4.7	13	7.5	105.2	-76.68	58
75	25	123.91	14	12	149.91	80	35	45	3.4	13	-	96.4	-53.51	64
50	50	142.59	14	12	168.59	80	35	45	3.5	13	9	105.5	-63.09	63
75	25	112.39	14	12	138.39	80	35	45	2.6	13	-	95.6	-42.79	69
75	25	144.51	14	12	170.51	80	35	45	5.2	13	15	113.2	-57.31	66
75	25	154.47	14	12	180.47	80	35	45	5.5	13	16	114.5	-65.97	63
LSD_{05}, kg													11.18	

Therefore, the intensity of the nitrogen balance in this crop rotation was the largest and made up 80%. In four-field crop rotation saturated with pea for grain to 25%, where pea was combined with spring wheat, buckwheat and spring barley the intensity of nitrogen balance made up 62, 66 and 63%, and the lack of nitrogen in these rotations amounted to 69.65, 57.31 and 65.97 kg/ha of crop rotation area. Chernozem could be enriched with nitrogen, possibly due to its non-symbiotic fixation by existing microorganisms. Therefore, partially lack of nitrogen could be reimbursed with resources, according to which the nitrogen deficiency at the level of 25-30 kg/ha per year is allowable [4]. Thus, the presence of pea for grain in crop rotation improves the removal of nitrogen from the soil and, despite its biological fixation creates a deficit balance. This fact is confirmed by other studies [6]: in the presence of legumes in rotation, due to rising yields on the nitrogen content in the plants, its removal by crops is growing.

Rotation with legumes crops provided close to a balanced nitrogen balance on condition of its removal with harvest only and utilizing by-products by subsequent ploughing into the soil (Table 2). The biggest indicator of the nitrogen balance intensity was observed in grain crop rotation (97%), due to symbiotic nitrogen fixation by microorganisms in crops of red clover.

Table 2

Nitrogen balance without removal by-products in short crop rotations with different saturation with grain and row crops (second rotation) (average for 2008-2011)

Saturation of crop rotation, %		Article of balance, kg/ha											Balance of nitrogen, kg	Balance intensity, %
		Expenditure				Supply								
Grain crops	Row crops	Total removal with harvest	With lysimetric water	Gaseous losses	Total	With fertilizers	Including organic	With mineral fertilizers	With seeds	With precipitation	Nitrogen fixation from the air	Total	Per 1 ha of area/year	
50	25	117.93	14	12	143.93	80	35	45	2,3	13	44	139.3	-4.63	97
75	25	117.30	14	12	143.30	80	35	45	6,3	13	16	115.3	-28	80
50	50	124.76	14	12	150.76	80	35	45	4,7	13	7,5	105.2	-45.56	70
75	25	86.94	14	12	112.94	80	35	45	3,4	13	-	96.4	-16.54	85
50	50	112.00	14	12	138.00	80	35	45	3,5	13	9	105.5	-32.5	76
75	25	80.04	14	12	106.04	80	35	45	2,6	13	-	95.6	-10.44	90
75	25	102.00	14	12	128.00	80	35	45	5,2	13	15	113.2	-14.8	88
75	25	114.10	14	12	140.10	80	35	45	5,5	13	16	114.5	-25.6	82
LSD_{05}, kg													10.02	

In rotation with row crops saturation to 50%, in link with maize + soybean for silage nitrogen deficiency made up 45.56 kg/ha, which was partially compensate with soil reserves, against 76.68 kg/ha for the total removal of the main harvest and by-products. In rotation saturated with grain crops to 75% without legume crops where buckwheat and spring barley were precursors to the sugar beet, there was less intense nitrogen balance of 16.54 and 10.44 kg/ha, due to much lower yields of winter wheat and sugar beet due to the deterioration of their predecessors.

Conclusions. Saturation of grain-row four-field rotation with row crops up to 50% (in link with of maize + soybean for silage) in some rotations and the lack of legumes (replacing them at the link on buckwheat and spring barley) in others creates a negative nitrogen balance from 42.79 to 76.68 kg/ha of crop rotation area. Therefore, in these rotations it is necessary to increase doses of nitrogen from 8% to 31%. Given the inclusion of by-products to fertilizing practice, virtually non-deficit balance of nitrogen in crop rotation is formed if the share of legumes (red clover, pea for grain) is not less than 25% and row crops not more than 25%.

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Анотація

Леньшин О.Г.

Баланс азоту в чотирипільних сівозмінах за різного використання побічної продукції в умовах Лісостепу України

Наведено результати досліджень з впливу насичення чотирипільних сівозмін зерновими (від 50 % до 75 %) та просапними культурами (від 25 % до 50 %), на фоні використання побічної продукції культур сівозміни у якості органічного добрива на інтенсивність балансу азоту. Встановлено, що за умови включення побічної продукції до системи удобрення, створюється практично бездефіцитний баланс азоту в тих сівозмінах, де концентрація бобових культур (конюшина лучна, горох на зерно) становила не менше 25 %, а просапних – не більше 25 %.

Ключові слова: *баланс азоту, органічні та мінеральні добрива, сівозміна, зернові культури, просапні культури, побічна продукція*

Аннотация

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Баланс азота в четырёхпольных севооборотах при разном использовании побочной продукции в условиях Лесостепи

Приведены результаты исследований по влиянию насыщения четырёхпольных севооборотов зерновыми (от 50 % до 75 %) и пропашными культурами (от 25 % до 50 %) на фоне использования побочной продукции культур севооборота в качестве органического удобрения на интенсивность баланса азота. Установлено, что при условии включения побочной продукции в систему удобрения создается практически бездефицитный баланс азота в тех севооборотах, где концентрация бобовых культур (клевер луговой, горох на зерно) составляла не менее 25 %, а пропашных – не более 25 %.

Ключевые слова: *баланс азота, органические, минеральные удобрения, севооборот, зерновые культуры, пропашные культуры, побочная продукция*