

Recycling and balance of nutrients at alternative fertilizer systems of sugar beet

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The purpose. To study features of recycling of nutrients in agrocenosis of sugar beet and to generate their equilibrated balance at alternative organic-mineral fertilizer systems. **Methods.** Short-term field and laboratory-analytical with mathematical processing of the gained results. **Results.** They show circulation and balance of nitrogen, phosphorus and potassium at cultivation of sugar beet with the use of traditional and alternative fertilizer systems. **Conclusions.** Use at cultivation of sugar beet of 5 t/hectare of straw + green manure crop + $N_{90}P_{60}K_{90}$ + N_{50} + Maximus, 4 kg/hectare is specified by highly efficient and ecologically balanced fertilizer system. Such application of fertilizers formed the equilibrated balance of nutrients in agrocenosis of sugar beet: nitrogen and phosphorus — 5 kg/hectare + 10 kg/hectare accordingly, and deficiency of potassium (at level of 69 kg/hectare). Use as fertilizer of haulm of sugar beet refunded in soil 49% of nitrogen, 40% of phosphorus, and 50% of potassium (from their economic removal). That made it possible to enter 139 kg/hectare of nitrogen, 35 kg/hectare of phosphorus, and 161 kg/hectare of potassium under the next crop in rotation in the form of easily accessible organic compounds.

Key words: *nutrients, balance, recycling, sugar beet.*

Introduction. Modern technologies of growing crops require reduction of economic costs and biogenic loading in agroecosystems [1], [2], [3]. Application for the fertilizer of the by-products of cultivated crops enriches the soil with organic matter, reduces the volume of nutrients removal from the soil and due to the processes of recirculation improves the nutrition of plants [4], [5]. Alternative organic-mineral systems of fertilizers with application of winter wheat straw and green mass of white mustard can significantly reduce the cost of using fertilizers, while ensuring the sustainability of crop growing technologies [6], [7], [8], [9]. In the conditions of the acute deficit of manure shortage and application the alternative system of sugar beet fertilization deserves special attention as it allows achieving high its productivity on the basis of ecologically balanced and economically efficient use of fertilizers [10], [11].

Research purpose was to study the peculiarities of the recycling of nutrients in the agro-cenosis of sugar beet and to form a balanced balance of them under alternative organic-mineral systems of fertilizers.

Materials and research methods. The research was carried out in the conditions of the stationary field experiment (2015-2017) of the Uladovo-Lulinetska research-breeding station, the zone of sufficient moisture of the Forest-Steppe of Ukraine.

Drilling area – 75 m², accounting area – 50 m², placement of the variants in experiments – systematic consistent, repetition of the experiment is four times. The sugar beet hybrid – “Bulava”, cultivation agrotechnic is generally accepted for the Forest-Steppe Zone.

Soil of the research plot is leached black soil which characterized by the following agrochemical properties: organic matter content by Turin – 4.0-4.2%, pH salt solution – 5.9-6.5, hydrolytic acid (Hg) by Kappen – 1.18-1.30 mg-equ./100 g of soil, sum of absorbed bases (S) by Kappen-Gilkovits – 24.4-27.6 mg-equ./100 g of soil, alkaline hydrolyzed nitrogen at Cornfield – 130-140 mg/kg of soil, mobile phosphoric and potassium by Chirikov – 140-160 and 75-80 mg/kg of soil.

Fertilizers were applied in the form of ammonium nitrate, simple granular superphosphate and potassium chloride. Organic fertilizers were applied in the form of alternative sources of the organic matter – the green

mass of the after harvesting green manure crop of mustard white (average yield – 26 t/ha) and straw of winter wheat – 5 t/ha .

When carrying out calculations of the balance of nutrients in agroecosystem of the beet sugar the nutrient supply to the soil with straw of winter wheat predecessor or green manure were not taken into account.

The content of nutrients in vegetative samples was determined after wet ashing by Ginzburg and etc.: nitrogen – by Keldal according to DSTU 7169-2010, phosphorus – according to GOST 26657-97, potassium – on a flame photometer.

Research results and their discussion. Studies carried out in the temporary field experiment of the Uladovo-Lulinetska research-breeding station shown that the use of alternative organic-mineral systems of fertilizers ensured the yield of sugar beet at the level of 59-65 t/ha, which exceeded the control without fertilizers per 14,9-21,3 t/ha. Under such yield, the sugar beet plants with roots have taken: nitrogen – 119-146 kg/ha, phosphorus – 40-50, potassium – 128-158; leaves – respectively 115-139, 20-33 and 137-161 kg/ha (table 1).

Table 1. Removal of the nutrients by sugar beet plants at the harvest period, average 2015-2017, kg/ha

№ var.	Variant		Roots yield, t/ha	Removal by roots			Leaves yield, t/ha	Removal by leaves		
				N	P ₂ O ₅	K ₂ O		N	P ₂ O ₅	K ₂ O
1	Without fertilizers (control)		44,2	85	29	93	28,1	88	20	102
2	5 t/ha straw of winter wheat	Without fertilizers (control)	47,1	93	31	99	29,3	90	20	106
3		N ₉₀ P ₆₀ K ₉₀	59,1	119	40	128	35,7	115	26	137
4		N ₁₂₀ P ₉₀ K ₁₂₀	59,6	125	41	136	35,8	115	27	138
5		N ₉₀ P ₆₀ K ₉₀ + *N ₅₀	61,7	132	43	140	37,6	124	27	143
6		N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀	62,2	137	44	144	38,0	127	28	147
7		N ₉₀ P ₆₀ K ₉₀ + *N ₅₀ + Maximus, 4 kg/ha	63,2	137	45	145	40,1	136	30	158
8		N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀ + Maximus, 4 kg/ha	63,2	137	44	147	40,7	136	31	159
9		5 t/ha straw + green manure (mustard)	Without fertilizers (control)	47,3	92	32	102	28,7	88	21
10	N ₉₀ P ₆₀ K ₉₀		60,2	122	43	136	37,1	120	28	140
11	N ₁₂₀ P ₉₀ K ₁₂₀		61,5	129	44	144	37,7	123	28	143
12	N ₉₀ P ₆₀ K ₉₀ + *N ₅₀		62,6	133	45	147	37,8	129	30	148
13	N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀		63,3	143	47	150	39,4	136	31	157
14	N ₉₀ P ₆₀ K ₉₀ + *N ₅₀ + Maximus, 4 kg/ha		65,1	145	50	159	40,7	139	33	161
15	N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀ + Maximus, 4 kg/ha		65,5	146	50	158	40,3	136	32	158
NIR _{0,05}	fund of organic fertilizers		1,1	-	-	-	0,6	-	-	-
	system of fertilizers		2,4	-	-	-	1,4	-	-	-
	total		3,3	-	-	-	1,8	-	-	-

* Compensatory dose of nitrogen

For the use of different combinations of fertilizers under sugar beet on the fond of 5 t/ha straw + green manure, the yield of roots compared with the application of fertilizers on the fond of straw was slightly higher – per 1.1-2.3 t/ha, which was accompanied by an increase in economic withdrawal of nitrogen – per 8-12 kg / ha, phosphorus - per 5-8, potassium - per 11-17 kg / ha.

The highest removal of nutrients was observed for the application of 5 t/ha straw + green manure + N90P60K90 + N50 + Maximus, 4 kg/ha: economic removal of nitrogen – 284 kg/ha, phosphorus – 83, potassium – 320 kg/ha. Compared to the growing of sugar beet on the fond of organic fertilizers (5 t/ha straw + green manure), the economic removal of nitrogen increased – per 104 kg/ha, phosphorus - per 30, potassium – per 110 kg/ha.

The application of a single dose of fertilizers (5 t/ha straw + green manure + N90P60K90) compared with repeated application of them on the fond of organic fertilizers reduced the yield of sugar beet per 4.9 t/ha and was accompanied by a decrease in economic withdrawal of nitrogen – per 42 kg/ha, phosphorus – 12, potassium – per 44 kg/ha.

For multiple use of fertilizers on the fond of straw application (straw + N90P60K90 + N50 + Maximus, 4 kg/ha), the economic removal of nitrogen was 273 kg/ha, phosphorus – 75, potassium – 303 kg/ha, which in comparison with the only straw application was higher – respectively per 90, 24 and 98 kg/ha; in comparison with the addition of 5 t/ha straw + N90P60K90 – respectively per 39, 9 and 38 kg/ha.

Thus, the application of alternatives organic-mineral fertilizers for sugar beet in comparison with crop cultivation on the fond of only organic fertilizers significantly increased yields and increased the removal of nutrients with economic yield in 1.3-1.5 times.

Alternative systems of fertilizers with the use of by-products involved a significant amount of nutrients to the processes of recirculation, turning nitrogen from its economic removal – on 48-51%, phosphorus – on 39-41%, potassium – on 50-52%. The specified amount of nutrients after the rapid mineralization of the sugar beet leaves served as a source of nutrition for the next crop, which was mainly grown on **aftereffect** of fertilizers. When plowing in leaves of sugar beet, the next crop in rotation received nitrogen in easily accessible form – 88-139 kg/ha, phosphorus – 20-33, potassium – 102-161 kg/ha. An alternative organic-mineral system of fertilizers created a solid basis for increasing the yield of crops grown in the **aftereffect** of fertilizers, providing them with a sufficiently high amount of nutrients in easily accessible forms (table 2).

Table 2. Balance and recirculation of the nutrients in the agroecosis of sugar beet, average 2015-2017

№ var.	Variant	Balance, ± kg/ha			Recirculation, %			
		N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	
1	Without fertilizers (control)	-86	-29	-93	51	41	52	
2	5 t/ha straw of winter wheat	Without fertilizers (control)	-93	-31	-99	49	39	52
3		N ₉₀ P ₆₀ K ₉₀	-29	+20	-38	49	39	52
4		N ₁₂₀ P ₉₀ K ₁₂₀	-5	+49	-16	48	40	50
5		N ₉₀ P ₆₀ K ₉₀ + *N ₅₀	+8	+17	-50	48	39	51
6		N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀	+33	+46	-24	48	39	51
7		N ₉₀ P ₆₀ K ₉₀ + *N ₅₀ + Maximus, 4 kg/ha	+3	+15	-55	50	40	52
8		N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀ + Maximus, 4 kg/ha	+33	+46	-28	50	41	52
9		5 t/ha straw + green manure (mustard white)	Without fertilizers (control)	-92	-32	-102	49	40
10	N ₉₀ P ₆₀ K ₉₀		-32	+17	-46	50	39	51
11	N ₁₂₀ P ₉₀ K ₁₂₀		-9	+46	-24	49	39	50
12	N ₉₀ P ₆₀ K ₉₀ + *N ₅₀		+7	+15	-57	49	40	50
13	N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀		+27	+43	-30	49	40	51
14	N ₉₀ P ₆₀ K ₉₀ + *N ₅₀ + Maximus, 4 kg/ha		-5	+10	-69	49	40	50
15	N ₁₂₀ P ₉₀ K ₁₂₀ + *N ₅₀ + Maximus, 4 kg/ha		+24	+40	-38	48	39	50

Note: balance – when leaving the leaves of sugar beet on the field; recirculation – from economic removal

The return to the soil of the leaves significantly reduced the nutrient load in the agroecosystem of sugar beet. Calculations of the balance of nutrients for plowing on fertilizer leaves of the sugar beet showed that roots of sugar beet crops with the yield of 60-65 t/ha have removed from the soil: nitrogen – 122-146 kg/ha, phosphorus – 43-50 kg/ha, potassium – 136-159 kg/ha, which was 50-60% from the economic removal.

For growing sugar beets on the background of 5 t/ha of straw without fertilizers with the subsequent plowing in the soil of the leaves, the sugar beet plants removed from the soil: nitrogen – 93 kg/ha,

phosphorus – 31, potassium – 99; on the background of 5 t/ha straw + green mass of mustard white – respectively 92, 32 and 102 kg/ha.

When applying 5 t/ha straw + N90P60K90 + N50 + Maximus, 4 kg/ha, it was formed a balanced balance of nutrients in agroecosystem of sugar beet plants by nitrogen and phosphorus – respectively +3 kg/ha and +15 kg/ha; with a deficit of potassium at a level of 55 kg/ha.

For the application of 5 t/ha straw + green manure + N90P60K90 + N50 + Maximus, 4 kg/ha, the balance of the nitrogen was slightly negative – -5 kg/ha, phosphorus – +10 kg/ha, potassium – -69 kg/ha.

Thus, the formation of stable conditions for sugar beet cultivation and receiving the yield of the roots at the level of 60-65 t/ha for the alternative organic-mineral systems of fertilizers requires the application of nitrogen fertilizers at the level of 140 kg/ha, phosphorus – 50 kg/ha, potassium – 160 kg/ha.

Conclusions

1. In conditions of sufficient moisture, the most effective alternative organic-mineral system of fertilizers was defined 5 t/ha straw + green manure + N90P60K90 + N50 + Maximus, 4 kg/ha. The application of the specified amount of organic and mineral fertilizers allowed the yield of sugar beet roots to 65.1 t/ha, and when plowing in leaves for the fertilizer, the plants carried out from the soil: nitrogen – 145 kg/ha, phosphorus – 50 kg/ha, potassium – 159 kg/ha, which was 50-60% from their economic take-up.

2. Application under the sugar beet of 5 t/ha straw + green manure + N90P60K90 + N50 + Maximus, 4 kg/ha formed a balanced balance of nutrients in agroecosystem of sugar beet plants by nitrogen and phosphorus – respectively -5 kg/ha and +10 kg/ha; with a deficit of potassium at 69 kg/ha.

3. By biologization of sugar beet cultivation (return leaves to the soil) and alternative organic-mineral system of fertilizers due to the processes of recirculation, into the soil it was returned from their economic removal: nitrogen – 48-50%, phosphorus – 39-41%, potassium – 50-52%. This allowed for the following crop in the rotation in the form of easy available organic compounds to apply nitrogen – 115-139 kg/ha, phosphorus – 20-33, potassium – 137-161 kg/ha.

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