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Agrochemical indexes of black earth depending on fertilizer system of sugar beet and links of crop rotations

Ya. Tsvei,
Doctor of Agricultural Sciences, Professor
O. Torlina,
N. Voroniuk
Institute of Bioenergy Crops and Sugar Beet NAAS of Ukraine

The purpose. To study influence of links of crop rotations on the content of mineral nitrogen, mobile phosphorus, exchangeable potassium depending on application of fertilizers, postharvest residues of winter wheat in sugar beet sowings**. Methods**. Field, laboratory**. Results**. 3-years results of study of influence of mineral and organic fertilizers in the form of straw upon agrochemical indexes of typical weakly alkaline black earth in conditions of Forest-steppe are brought. **Conclusions**. At application of organomineral fertilizer system agrochemical indexes of typical weakly alkaline black earth are increased. During period of shoots of sugar beet use of straw + $N_{140}P_{120}K_{90}$ heightened the content of mineral nitrogen within the limits of 18,3-20,8, mobile phosphorus — 43,0 – 50,7, exchangeable potassium — 125 – 135 mg/kg of soil. That did not yield to alternative with importation of dung in dose of 25 t/hectare + $N_{90}P_{120}K_{90}$.

Key words*: typical weakly alkaline black earth, content*

Problem statement. The system of crop rotation and fertilization affects the formation of the nutrient regime in the soil, the mobility and availability of nutrients, mineralization and immobilization processes in the soil (Barshtein et al. 2002,Hospodarenko2002,Nechaev et al. 2013,Poliovyi 2007,Tsvei 2014).

Under the effect of long-term regular application of manure and mineral fertilizers on chernozem soils, the nutrient content of the soils improved (Barshtein et al. 2002,Poliovyi 2007, Shymanska 1994).

For the systematic introduction of manure and mineral fertilizers, there was an increase in the content of mobile phosphorus and exchange potassium in the soil (Ivanina et al. 2013, Zarishnyak et al. 2013, Nosko 1990, Nikitshen et al. 2000, Tsvei 2014).

In modern agriculture, using by-products of grain crops as organic fertilizer improves nitrogen, phosphorus, and potassium regime of the soil, since harvest residues contribute to the recycling of nutrients in the soil- plant system (Hospodarenko2002,Nikitshen et al. 2000,Poliovyi 2007,Tsvei 2014,Shiyan 1992, Shymanska 1994).

Research by Nosko(Nosko 1990) on leached chernozemindicated that application ofP_{34}, both separately and with straw (3 t/ha),led to the optimal phosphorus balance. Positive potassium balance was noted when K_{18} was added against the background of 3 t/ha straw.

The **purpose of the research** was to determine the effect of crop rotation links on the content of mineral nitrogen, mobile phosphorus and exchange potassium as affected by application of fertilizers and harvest residues of winter wheat straw in sugar beet sowings (Table 1).

Research methods. The research was carried out at Veselopodilska RBS (Semenivka district, Poltava region) in a long-term stationary experiment on typical deep weakly-sodicchernozem of the following characteristics: pH_{sal} of 7.5, humus (by Tiurin) 4.5 to 4.8%; P_2O_5 and K_2O (by Machigin) 30 and 100 mg/kg, respectively. The alternation of crops in short rotation was as follows: grain – row crop rotation: 1) corn for silage, 2) winter wheat, 3) sugar beet, 4) barley (50% row crops, 50% grain crops);grain – row crop rotation: 1) pea, 2) winter wheat, 3) winter wheat, 4) sugar beet (75% grain crops, 25% row crops); grain – fallow – row crop rotation: 1) bare fallow, 2) winter wheat, 3) sugar beet, 4) barley (25% bare fallow, 25% sugarbeet, 50% grain crops). Agrochemical analyseswere conductedat the period

of germination and harvesting sugar beet. Mineral nitrogen (NH_4+NO_3) was determinedby CINAOmethod, mobile phosphorus and exchange potassium by Machigin method. The fertilization practices used in the experiment are shown in Table 1. In the experiment, sugar beet hybrid Bulavawas grown according to generally accepted agronomical practices for the zone of sugar beet growing.

Research results indicate that the application of different fertilizationpractices in the cultivation of sugar beet has an effect on the nitrogen regime in the soil. Consequently, the level of mineral nitrogen in the soil during the period of sugar beet emergence in the treatments without fertilizers was as following: in the link with corn for silage 14.6, bare fallow 14.3 and in 2 fields of winter wheat 14.2 mg/kg. Application of mineral and organic fertilizers improves the provision of soil with nitrogen due to the strengthening of nitrification and ammoniation processes in the soil (Hesse 1986, Muller &Feyerabend 1979).

The research showed that for the application of 25 t/ha manure +$N_{90}P_{120}K_{90}$, the content of mineral nitrogen of the soil was as follows: for the period of sugar beet emergence in grain – row crop rotation in the link with corn for silage it was 18.6 mg/kg, in grain – row crop rotation, where sugar beets were sown on two fields following winter wheat 19.8 mg/kg, in grain – fallow crop rotation in the linkof bare fallow 20.7 mg/kg, which was more than by 4.0, 5.6 and 6.4 mg/kg, respectively, compared to the treatment without fertilization.

According to the crop rotation, the content of mineral nitrogen in soil increased by 2.1 mg/kg due to the effect of mineralization processes and the release of NH_4 and NO_3 compounds in the soil. In those options of crop rotation, where a combination of manure, straw and mineral fertilizers was introduced, the content of mineral nitrogen was affected by the course of mineralization and immobilization processes. The highest content of mineral nitrogen of the soil was observed in the link of corn for silage, specifically 21.1 mg/kg, which exceeded the organic &mineral fertilization practice by 2.5 mg/kgand bare fallow by 0.6 mg/kg only.

The combination of straw with mineral fertilizers had a special effect on the formation of the nitrogen regime of the soil during the beet sugar growing. Thus, during the period of sugar beetemergence, 5 t/ha of straw + $N_{140}P_{120}K_{90}$ in the link of corn for silage led to the mineral nitrogen content in the arable soil layer of 20.8 mg/kg, in the link of bare fallowand two fields of winter wheat 18.3 and 18.7 mg/kg,respectively, which was higher than in the treatment without fertilization by 6.2, 4.0, and 4.5 mg/kg, respectively. Under the effect of fertilization, migration of mineral nitrogen into the under-ploughed layer of soil was observed.

By the end of the sugar beet vegetation, the content of mineral nitrogen decreased both due to the assimilation by plants, and slowing down of nitrification and ammonification processes in the soil.

Thus, from the use of 25 t/ha of manure + $N_{90}P_{120}K_{90}$ under sugar beet, an increase in mineral nitrogen content in the under-ploughedsoil layer was observed compared to theunfertilized backgrounds, specifically, in grain – row crop rotationin the link ofcorn for silage, this indicator increased by 3.9; in the grain –fallow – row crop rotation in the link ofbare fallow by 4.9 and winter wheat by 2.4 mg/kg. Such growth was due to the migration of NO_3 compounds to the lower layers of the soil.

By the end of sugar beet growing season, the content of mineral nitrogen in the soil decreased both due to the use of itby plants, and slowing down of nitrification and ammoniation processes in the soil.

Practice of the organic & mineral fertilization improves phosphate regime of chernozem soils (Nosko 1990, Nikitshen et al. 2000, Kochl 1982). Thus, for the application of 25 t/ha of manure +$N_{90}P_{120}K_{90}$, the content of mobile phosphorus in the soil amounted to 52.2 mg/kg during the period of sugar beet emergence, in the link of corn for silage, in 2 fields of winter wheat 45.7 mg/kg, and in the link of bare fallow 51.3 mg/kg, which was greater than in the unfertilized treatment by 22.9, 15.6, and 18.3 mg/kg, respectively. Consequently, organic & mineral fertilization ensure a substantial increase in the content of mobile phosphorus in the soil.

In the treatment where 25 t/ha of manure + straw + $N_{90}P_{120}K_{90}$was used, the content of mobile phosphorus of the soil in the link of corn for silage was 51.2 mg/kg, in two fields of winter wheat 49.8 mg/kg and in the link of bare fallow 50.5 mg/kg.

Under introduction of 5 t/ha straw +$N_{140}P_{120}K_{90}$, the mobile phosphorus content in the ploughed soil layer was as follows: in the link of corn for silage 50.7, in the link of bare fallow 45.0, and winter wheat 43.0 mg/kg, which was almost not inferior to the above described fertilization practices.

Under the effect of fertilizers, an increase in the content of mobile phosphorus in the under-ploughedsoil layer was observed. To illustrate, in the soil layer of 30-60 cm, mobile phosphorus content against the background of 25 t/ha of manure + straw + $N_{90}P_{120}K_{90}$ in the link of corn for silage increased to 37.0, in the link ofbare fallow to 38.0 and winter wheat to 39.3 mg/kg, which exceeded the unfertilized background by 14.0, 15.0, and 11.3 mg/kg, respectively. At the end of sugar beet growing season, mobile phosphorus content of the soil decreased both due to the assimilation by plantsand the transition of phosphates into slow-moving compounds.

Typical weakly sodicchernozemshave a high level of supply with exchange potassium. At the same time, both in mineral and in the organic &mineral fertilization systems there is an increase in P content (Hospodarenko 2002, Ivanina et al. 2013,Zarishnyak et al. 2013,Poliovyi 2007). In the treatment where 25 t/ha of manure + $N_{90}P_{120}K_{90}$wasapplied at the beginning ofsugar beet vegetation in the link of corn for silage, P content in the ploughed soil layer was 131.0, whereas in 2 fields of winter wheatit was 131.0 and in the link of bare fallow 129.0 mg/kg, which was higher than in the unfertilized treatments by 40.0, 37.0, and 37.0 mg/kg, respectively. When applying 25 t/ha of manure + straw + $N_{90}P_{120}K_{90}$, P content in thesoil was 135.0, 154.0 and 149.0 mg/kg, respectively, indicating a slight increase due to application of 25 t/ha of manure +$N_{90}P_{120}K_{90}$.

In the treatment, where straw and mineral fertilizers were combined, the content of exchangeable potassium in the arable layer of soil was at the same level with the option of 25 t/ha of manure +$N_{90}P_{120}K_{90}$. The highest content of P of the soil was observed in the link of corn for silage, specifically 135.0 mg/kg, while in the link of bare fallow it was 130.0 mg/kg.

Consequently, the combination of straw with mineral fertilizers contributes to the optimal content of exchangeable potassium in the soil.

In the under-ploughedsoil layer, there was an increase in the content of exchangeable potassium compared to unfertilized treatments. For the above mentioned fertilization practice, the content of exchangeable potassium in the soilin the link of corn for silage ranged from 89.0 to 102.0, in the link of bare fallow from 96.0 to 113.0, in 2 fields of winterwheat from 85.0 to 102.0 mg/kg, whereas without fertilizers the range was 63.0 to 72.0 mg/kg.

By the end of the sugar beet vegetation, the content of exchangeable potassium decreased both due to the use by plants and transition to unexchange fixed state. Thus, against the background of 25 t/ha of manure +$N_{90}P_{120}K_{90}$, P contentof the soil in the link of corn for silage was 110.0, in the link of bare fallow 114.0 and in the link of winter wheat 108.0 mg/kg, which was less than during period of beet sugar emergence by 21.0, 15.0, and 23.0 mg/kg, respectively; in the treatment with straw + $N_{140}P_{120}K_{90}$ it was 110,0, 109.0, and 116.0 mg/kg, respectively.

Consequently, the nutritional regime of typical weakly-sodicchernozemis more affected by fertilization practice for sugar beet, than by crop rotation links. Ploughing-in straw with manure and fertilizers helps to optimize the nutrient regime of the soil.

Table 1. Effect of fertilization practice forsugar beet and crop rotation links on agro-chemical indices (mg/kg)of typical weakly sodicchernozem in shortcrop rotations (VPRBS), average from 2012 to 2014.

No	Fertilizationpractice	Soil layer (cm)	NH_4+NO_3		P_2O_5		K_2O	
			1*	11**	1*	11**	1*	11**
Grain – rowcroprotation (corn for silage)								
27	No fertilizers	0-30	14.6	13.1	29.3	26.3	91.0	67.0
		30-60	12.0	10.7	23.0	21.0	63.0	49.0

28	25 t/ha manure + $N_{90}P_{120}K_{90}$	0-30	18.6	17.3	52.2	41.8	131.0	110.0
		30-60	15.7	14.6	35.0	31.3	102.0	82.0
29	25 t/ha manure+straw+$N_{90}P_{120}K_{90}$	0-30	21.1	18.6	51.2	42.3	135.0	125.0
		30-60	17.6	15.6	37.0	34.0	92.0	80.0
30	Straw + $N_{140}P_{120}K_{90}$	0-30	20.8	19.3	50.7	43.5	135.0	110.0
		30-60	12.8	14.2	39.7	36.0	89.0	69.0
Grain - fallow - rowcroprotation(bare fallow)								
45	No fertilizers	0-30	14.3	12.7	32.2	28.3	92.0	74.0
		30-60	11.5	9.3	23.0	20.3	72.0	52.0
46	25 t/ha manure + $N_{90}P_{120}K_{90}$	0-30	20.7	18.8	51.3	44.0	129.0	114.0
		30-60	16.3	14.2	35.3	28.7	96.0	83.0
47	25 t/ha manure +straw +$N_{90}P_{120}K_{90}$	0-30	21.3	19.2	50.5	45.8	149.0	114.0
		30-60	16.7	14.5	38.0	30.3	113.0	79.3
48	Straw + $N_{140}P_{120}K_{90}$	0-30	18.3	17.4	45.0	40.0	130.0	109.0
		30-60	13.7	13.5	30.3	28.3	102.0	68.0
Grain - rowcroprotation (two fields of winter wheat)								
63	No fertilizers	0-30	14.2	12.7	34.2	30.2	94.0	85.0
		30-60	12.5	10.3	28.0	25.0	71.0	56.0
64	25 t/ha manure + $N_{90}P_{120}K_{90}$	0-30	19.8	17.9	45.7	41.7	131.0	108.0
		30-60	14.4	12.7	35.7	31.3	89.0	79.0
65	25 t/ha manure +straw +$N_{90}P_{120}K_{90}$	0-30	20.6	18.2	49.8	46.2	154.0	124.0
		30-60	14.4	12.9	39.3	33.6	102.0	73.0
66	Straw + $N_{140}P_{120}K_{90}$	0-30	18.7	17.5	43.0	40.2	125.0	116.0
		30-60	13.8	12.6	34.7	31.0	85.0	80.0

*1 emergence; **11end of vegetation period.

Conclusions

The study has proved that combination of 25 t/ha of manure + straw + $N_{90}P_{120}K_{90}$0increasesthe content of mineral nitrogen of the soil during the period of sugar beet emergencefrom 20.6 to 21.3 mg/kg, whereas the application of 25 t/ha of manure + $N_{90}P_{120}K_{90}$increase mineral nitrogen content of the soil by 17.3- 18.8 mg/kg.

Introduction of 25 t/ha of manure + straw + $N_{90}P_{120}K_{90}$contributed to the increase in mobile phosphorus content of soil by 26.3-30.2 mg/kg as compared to unfertilized background. At the end of the sugar beet vegetation, the content of mobile phosphorus decreased, due to the uptake by plants.

Ploughing-in straw contributed to the improvement of the potassium regime of typicalchernozem. Against the background of 25 t/ha of manure + straw + $N_{90}P_{120}K_{90}$, the content of exchange potassium of the soil increased at the period of sugar beet emergence by 44.0 - 60.0 mg/kg as compared to unfertilized backgroundand ranged from 135.0 to 154.0 mg/kg. At the end of vegetation, the content of exchange potassium decreased by 10 - 23 mg kg.

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