

PHOSPHATE STATE OF DIFFERENT CENOZES OF BLACK SOILS IN USUAL NORTH STEPPE OF UKRAINE

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В результаті проведених досліджень здійснена порівняльна оцінка вмісту рухомих форм фосфору у чорноземах звичайних на цілинних землях і на ріллі. Встановлено, що близьким до оптимальних показників є вміст рухомих форм фосфору тільки на ґрунтах з довготривалим обробітком. Для забезпечення високих урожаїв на чорноземі звичайному необхідно вносити фосфорні добрива так само, як і на ґрунтах іншого типу.

Ключові слова: *цілинні землі, рілля, фосфатний режим, рухомі форми поживних речовин.*

Near to nitrogen the second important element of mineral feeding, which in the most of cases limits the further growth of corn's yield by all crops, is phosphorus, because phosphorus is a backbone of steady agriculture in all zones. "Each farmer must remember it" – many times stressed academic V. D. Pannikov in his scientific works. However, the very important stages of plant's ontogenies and formation agrocenoses' productivity in almost all crops depend on level of its assimilation and metabolism.

For fairness it may be said, that on basis of perennial field's and vegetative researches D. M. Pryanishnikov in 1924 invented the first soil-agrochemical map of former USSR, on which he refereed zone of black soil, and also our steppe's soils, to areas, which urgently require applying of phosphorus' fertilizers. He wrote that in black soils there are "great deposit of nitrogen, the necessary quantity of potassium: we need to add only one element – it's phosphorus to reduce of black soil, which was exhausted by long-term crop without fertilizers from times of Russian Crossing or earlier"[1].

It's connected with that fact in the most of soil's types phosphorus is found in weak-soluble mineral and organic forms, and almost all crops, with the exception of those types (buckwheat, lupine, peas) in which proportion $\text{CaO}/\text{P}_2\text{O}_5$ is more than 1,3, are able to absorb P_2O_5 with $\text{Ca}_3(\text{PO}_4)_2$, and dissolve phosphates by its exudates or release phosphorus at expense of intensive absorption from soil's solution cations of Calcium, so spring and winter cereals spike crops absorb only its movable form [2]. Spring and winter cereals crops (wheat, barley, triticale, rye, corn) weak assimilate hard-soluble phosphorus combinations from soil, that's why it well react to applying of easy-soluble forms of phosphorus fertilizers, so it energetically absorb phosphorus and the less – calcium. That's why in steppe's conditions on the first place there is phosphoric, and than – nitrogen and other types of plant's feeding [3]. In this zone the part of phosphoric fertilizers in yield's growth of cereals crops consists 30–60, nitrogen – 15–40 and for potassium – only 0–20 %. Certainly, particularly important role of movable phosphorus' forms shows itself on beginning of growth and development of plants, therefore it definitely applies into soil premature. Elder plants weaker react to lack of this element of feeding. This element decreases the negative action of surpluses nitrogen fertilizing, optimizes using of nitrogen, increases the effectiveness of nitrogen fertilizers [4].

But near to this, the optimal soil's providing with movable forms of this feeding element is also important during the ontogenesis. But in the most of soils the movable forms of this important element of mineral plants' feeding is found in minimum and reserve the further yielding growth of crops [5]. To the point we must to note that in Ukraine area of arable land with low and average content of movable phosphorus amounts to 17 812 hectares, or 57 % of common area [6]. Thought the low providing soils with available for plants phosphorus occupies of phosphoric fertilizers is too high – in average 1 kg P_2O_5 provides growth 4–5 kg of corn. As a result of reduction phosphorus content in the soil in nearing years in Ukraine the decreasing productivity of sowing will reach to 2,2 of corn unit [7].

The paradox of problem phosphorus feeding of plants consists in that the gross deposits of phosphorus in the most soils are considerable, but for 40 % areas of world's arable lands the pro-

ductivity of cereals crops limits by lack of phosphorus movable forms [3]. It is explained that in composition of gross phosphorus deposits in meter's stratum of soils the weak-soluble forms occupy a prevailing status, and, on the contrary, content of movable forms is insignificant and it doesn't always correspond to plants' needs [8]. So effective fertility of most soils amount to insufficient providing it by phosphorus' movable forms [9].

Besides, in contrast to other elements of organic soil's substance (C, H, O, N), which arrive into soil mainly from atmosphere, the basis primary source of phosphorus is soil-foundation maternal rock, which not always is able to provide in enough amount with soil's solution by movable phosphorus' forms [10]. It's also connected with that fact the phosphorus for its chemical qualities has a complex disposition of interaction with soil's components [10].

This circumstance greatly complicates the receiving an objective mark of soil's providing by this element of mineral plants' feeding. So for avoiding its deficit, it is very important to receive timely information about content the movable phosphorus' forms in soil and supporting the optimal level available for plants of its forms during all ontogenesis, and applying the phosphorus' fertilizers [11]. The exact determination of indices phosphorus' movable forms in soil gives opportunity to use nature resources more effective and make forecast effectiveness of phosphorus' fertilizers [12, 13]. Wrong information about phosphate's state of soils, on the contrary, causes to non-effective using of fertilizers [14].

Applying the methods of determination of phosphorus' content without accounting concrete peculiarities of soils and also insufficient working off methodical aspects of plants' feeding diagnostics causes to distortion mark of soil's fertility state of whole regions [15]. It's connected with that fact the most methods are founded on using of extragents solutions of strong acids that testifies about their belonging to so-called strict methods [16]. Using of these methods on very sour soils causes to essential understating facts at expense of strong repeated absorption P_2O_5 at realization of analysis, but into soils, which have increased content of apatite-similar combinations it causes to their essential increasing [17]. Even very weak alkali of soils evokes partial neutrality of acid and also understating of received results [18]. The main criterion at choice of method for separating movable combinations of phosphorus from soil is valuation its ability to represent rightly plants' reaction on applying of phosphorus' fertilizers [19].

From aforesaid it becomes clear that movable (available) phosphorus plays particularly important role in mineral feeding of plants, and methodically right determination of its content in the soil's solution plays especially important role at realization calculation an optimal doses applying of phosphorus' fertilizers [20]. Because of that it is always not enough in soils' solution, so it forms small per cent from its gross forms available in soil [21].

For clear imagining of that, we need to carry out comparison of content in soil gross and movable phosphorus' forms [22]. This comparison shows that in black soils the usual content of gross phosphorus' forms (0,11–0,12 %) forms 1100–1200 mg/kg soil. And its movable forms are determined by Chyrykov's method, which cross in weak-acid dragging's 0,5N by acetic acid and partly take direct part in phosphorus' plants' feeding (98–167 mg/kg soil), they are contained in soil in small quantity and forms only 8,2–13,9 % from gross content of phosphorus [23]. So movable phosphorus' forms are in first minimum among other macroelements in these soils [24]. In scientific literature near to term «movable» for selection of available plant's forms from all totality of phosphorus' mineral combination, they often use other terms, which are synonyms to «assimilative, labial» phosphorus [25].

But indistinction of these terms disturbs to get objective mark to nutritious regime of specific soil. The term «movable» phosphorus, potassium and others erroneously have associations with concentration of specific feeding element in plants in soil's solution, which depends on soil's qualities and others factors. Movability is rather limit of availability element for plants. The content of movable forms of nutritious substances in extensive-used tillage is a constant for each element. The meaning of these constants defines by physical-chemical conditions, which are typical for Earth's surface. The illusion of different nature's providing with movable forms of plant's elements of feeding in different types of arable soils and diversion of specific field conditioned by imperfect of diagnostical normative and methodical aspects of plants' feeding.

According to classical definition by assimilative phosphorus isn't reliable chemical combination and isn't in ready view in soil. But it isn't very easily, about it witness the name of sole international standart, which determines the method of definition movable phosphorus in soils – ISO 11236 (spectrometerical method of definition phosphorus in solution hydrocarbonate of natrium). In it accent was made not on determination, but on how to determine and with a help of what.

We need to note that through uninterrupted absorption process of this nutritious element by plants, the concentration of available phosphorus is always low. As is generally known the plants are able to absorb the phosphorus from soil's solution even in little its concentration such as 0,01–0,02 mg/l P_2O_5 . Besides, in usual black soils the content of soluble into the water phosphates is able to reduce for vegetative period more than 100 times. Connection with that for normal growth and plants' development it is important not only the high its concentration in soils' solution, but ability of soil to replenish deposits of movable phosphorus and so to liquidate its deficit, that fact is observed in field conditions during mineral plants feeding.

In the present instance the capacity of phosphorus in soil for plants depends on its mobilization and immobilization, which connect with process of solution or precipitation, sorption and desorption, mineralization and biological allocation by its combinations. The main source of replenishment the soil's solution by movable phosphorus' forms is gross its deposits, which concentrated in maternal rock and in phosphorus-contentive organic soil's combinations. But near to them the essential role is playing by a part and water-soluble phosphorus combinations, which are received into the soil with mineral fertilizers [26].

As it was noted higher, the gross deposits of phosphorus into the soil are relatively high [27]. So in arable stratum of black soils the usual content of gross phosphorus forms is 0,11–0,12 %, and its gross deposits comparatively with nitrogen and potassium aren't big and they variate within the limits of 5,4–5,5 t/h, and in meters – 17,5–18,0 t/h [28], it is much lower than content in these soils of gross forms NK. The main quantity of gross phosphorus is in higher (0–25 sm) stratum of soil, it connects with plant's activity, its active absorption by soil and with applying of fertilizers [29]. As result of biological processes of transferring, in gumus' horizon its quantity is always more than in lower-disposed and maternal rock. As it was noted higher, the gross deposits are presenting by organic and mineral forms.

The organic phosphates (nuklein acid, fosfatyd, sugarphosphates and others), part of which is 10–15 % from common content of phosphorus, are unattainable for plants and take part in feeding only after their gidrolize and separating of phosphorus [30]. That is in main a way, phosphorus-organic soil's combinations are assimilate by plants only after their mineralization. But part of organic phosphorus frees by microorganisms, which takes direct part in mineral feeding of plants, is insignificant. It's connected with that fact at microbiological decomposition of phosphate-contentive organic combinations the phosphorus partly connects by microflora of soil, and then, after reproduction of these microorganizms, this pull of phosphorus again passes to their new colonies. And only four its per cent from common quantity is free and passes in mineral form after their disappearing. That's why the main role in mineral feeding of plants is occupied by mineral forms of phosphorus.

In usual black soils the content of mineral phosphorus' forms predominates over the organic. That's why the main role in phosphorus' feeding of plants is playing by mineral forms of phosphorus, notes that in soils it was found 250 available phosphorus-contentive minerals, which all are salts of ortophosphorus' acid. Generally, the mineral combinations of phosphorus are presenting by very much forms, which are mainly hard-soluble, generally little-movable forms and faint-accessible phosphates for plants. Mineral phosphates in soil are formed from many salts, which were formed from ortophosphorus' acid and are different for chemical composition and for level of availability for plants.

It comes to composition of minerals: phtorapatyt $Ca_5F(PO_4)_3$, gidroksylapatyt $Ca_3(PO_4)_2 \times Ca(OH)_2$ and vivianit $Fe_3(PO_4)_2 \times 8H_2O$. Among them the predominate status is belong to variety of apatyt's mineral, the main way, to phtoroapatyt. In maternal rock of usual black soils the phosphorus is in view of phtoroapatyt $Ca_5(F(PO_4)_3$ and calcium gidroksylapatyt $Ca_5(OH)(PO_4)_3$. In process of deterioration these primary phosphoro-contentive minerals the secondary phosphorus' mi-

neral combinations are formed, and they contain in their composition the different salts of orthophosphorus acid. The mineral forms of phosphorus in soil are presenting by salts of orthophosphorus acid, in which phosphate's anion chemically connects with cations Ca^{2+} , Mg^{2+} , Fe^{2+} , Al^{3+} , Mn^{2+} and others, the considerable part of which is in adsorbate state on surface of soil's colloids. The low their solubility and weak dissociation on ions is characteristic feature of phosphate's soil's combinations.

The phosphate's ions are well recorded by hard phase of soil and their migration in usual black soils is very limited. The intensive chemical absorption is typical for salts of orthophosphorus' acid, and it stipulates a weak movability of phosphorus' combinations. The speed of their diffusion in soil is insignificant and variates within the limits of 10^{-12} – 10^{-15} $\text{m}^2/\text{sec.}$, and it makes the assimilation of phosphorus by plants very hard, as a result of that the root's zone of plants quickly exhausts by this element of mineral plant's feeding. In connection with that the big rip arises between gross content of phosphorus in soil and its available quantity for plants.

The assimilation phosphate's anions by plants from heavy-soluble combinations goes off only from soil's solution, it is the basic point of plant's physiology. The assimilation phosphorus by plants from heavy-soluble phosphorus-contentive combinations goes off gradually and physiologists explain that root's hairs by their sour selections (exudates) transfer the apatites and phosphorites into solution not in full degree. Connection with that the problem of phosphorus in modern agriculture is rather acute, so we must to be disposed to this element of mineral feeding with special attention and care, and must constantly search for ways of the most rational its using in agrocenoses of cereals crops. The main source of mineral phosphorus for plants in usual black soils is one- and two-valentive anions of orthophosphorus acid. Among the available phosphorus' combinations in these soils the plants the easier assimilate the well-dissolved in the water salts of one-valentive cations K_2HPO_4 and KH_2PO_4 , and also two-replacing salts of Calcium orthophosphorus' acid CaHPO_4 .

The root's system is more adapted for absorption anion H_2PO_4^- and it worse assimilates HPO_4^{2-} , that is the plants better assimilate soluble in the water dehydrophosphates, than hydrophosphates, dissolved in the weak acids, that is connected with additional expenditures of energy. Besides, anion H_2PO_4^- easier adsorbs by the roots, than HPO_4^{2-} , means of which grows at high significances pH, because in the solution with pH higher than 7,2 this anion becomes predominative ions. The most researches show that the speed of phosphorus' absorption is the highest in range pH from 5,0 to 6,6, when in soil's solution anion H_2PO_4^- predominates.

The anions PO_4^{3-} haven't the practical meaning for plants. That is connected with the low solubility of carbonates calcium and magnium – $\text{Ca}_3(\text{PO}_4)_2$, which is minimum and is 0,33 mg P in 1 l. At the drying a part of dehydro- and hydrophosphate ions passes into phosphates of calcium and magnium, and the balance disturbs, but at the moistening of the soil it happens passing into the solution of additional quantity phosphatoions and the balance reduces. We must to note that in usual black soils a fixing of phosphorus' anions passes in result of their connection by the cations of calcium, magnium and aluminium.

At the facts of soils' agrochemical examination the content of phosphorus into them in 1966–1970 in average in Ukraine is 7,1 mg /100 g of soil. We must to note that at the phosphorus' content the soil's shroud is notable for more variegaty comparate to nitrogen. It's conditioned by the features of soil-making rocks and region's features of soil-making, and also by the level of agricultural intensivity.

At period 1966–1990 the amounts of applying phosphorus' fertilizers constantly grew. The common balance of phosphorus in 1971–1975 was positive (+3,9 kg/he P_2O_5), in the next periods (1976–1980) (+10,1 kg/he); (1981–1985) (+15 kg/he); (1986–1990) (+20,6 kg/he P_2O_5). At the facts of agrochemical examination (1991–1995) the areas of arable lands with increased and high phosphorus' content have grown and with low and average content were kept compare to the first tour of examination (1966–1970) on the level 30 %. The average-weight content of movable phosphorus in steppe zone has grown from 6,7 to 9,3 mg on 100g of soil.

Beginning from 1991 the level of applying phosphorus' fertilizers sharply decreases and in 1997 is 4,1 kg/he P_2O_5 . Every year the deficit of mineral phosphorus is 15–20 kg/he, that causes the

reduction of content phosphorus in the soil on 0,4–0,5 mg/100 g of soil. It gradually aggravates the phosphate's routine of usual black soils. The lowest quantity of phosphorus' fertilizers was applying in 2000 – only 2 kg/he P_2O_5 . In 2001–2002 also it was applying a little quantity of these fertilizers – 3 kg/he P_2O_5 .

The gradual growing of quantity of applied phosphorus' fertilizers was beginning from 2004 – 4 kg/he, the similar quantity was applying in 2005. In 2006 it was applying already 7 kg/he P_2O_5 , in 2007 – 10 kg/he P_2O_5 . From 2008 the tendency to decreasing the amounts of their applying again begins to observed, at first to 9 kg/he, and then in 2009–2010 – to 7 kg/he P_2O_5 . Such long-term applying of small amounts of phosphorus' fertilizers evokes the gradual worsening of phosphate's regime these soils to worked out forecast, at the full abeyance of applying phosphorus' fertilizers a content of phosphorus in soils will be reduced on 3,0–3,2 mg/100 g of soil and in such circumstances of managing the soils will fully lose that quantity of phosphorus, which was accumulated by them for the years of intensive chemicallyization.

It should be note that in big amounts the phosphorus' fertilizers are applying into the soil only in economically developed countries, such as Japan, USA, Great Britain, Germany, France, Denmark, Italy, China, which constantly increases the amounts of their applying. Moreover, in Germany even the problem of soil's phosphatering arises. So, in opinion of other authors, at the keeping of this tendency from now on, the deposits of phosphorus on the Earth could be exhausted already over 60–80 years, and the global top of using deposits phosphates' raw material, for forecast some researchers will be in 2040. In the most of world's countries, so that in Ukraine, the doses of applying these fertilizers are not high and the taking out of phosphorus from the soil by the received crop's yields predominates over its arriving with tucks.

With connection that to see the changes, which were happened with movable phosphorus' forms, and to compare a level of their movability in usual black soils on tillage at relation to virgin land the need in making researches has arose.

The scientific-experimental work was realized in Erastivka experimental station by SU Institute of agriculture in steppe's zone NAAN of Ukraine, where soils are usual black soils, the little-humus and hard-loam on les. In the arable soil's stratum of humus there is 3,8–4,1 % (Turin method), gross nitrogen 0,22–0,23, phosphorus 0,12–0,13, potassium 2,0–2,1 %. The level of nitrate's nitrogen after 7-days composting has changed from 31 to 52 mg/kg of soil. The movable phosphorus (after Chyrykov) – 110–112 mg/kg, movable potassium – 105–130 mg/kg. The reaction of soil's solution is neutral ($pH_{\text{water}} = 7,0$.)

For determination the changes, which were happened with movable phosphorus' forms in usual black soils under the influence of long-term their using in agricultural production there were made two soil's slits in depth – 2 m, in width – 3 m, in length – 6 m: the first is on virgine land near the village Baykivka Pyatykhatky district Dnipropetrovsk region, and the second is on tillage in the distance 300 m from the first. Beginning from the upper part of slits over each 5 sm on all depth they choosed the soil's samples for determination of content movable phosphorus' forms in them, this content was determining for Acid's method of Chyrykov (GOST 26204-91) and salt's method of Karpinskyi-Zamyatyna (DSTU 4727:2007). The determination of optical density of solutions was held on photoelectrocolorimeter KFK-2. The analyses were held in three-times analytical reiteration.

The tillage, which forms 53,8 % of Ukraine's territory, belongs to the most unstable landscape, and the nonobservance interchanging of agricultural crops at their growing, the disturbance of sowing-change, the dominance of monoculture and the abrupt decreasing the amounts of applying mineral and organic fertilizers intensify the agrochemical non-stability of agrolandscapes. The nonobservance of scientific zonal systems of agriculture, the disturbance of ecologically admissible correlation of agricultural crops cause to deficit into the soil the movable forms of nutritious substances and increase the areas of degradative lands, and evoke the ecological problems.

At the deterioration of the country and at the over-distribution of lands the sowing-changes were disturbed. According to the indices of Dershkomstat of Ukraine the sowing areas of basic agricultural crops in Ukraine in 1990–2010 were decreased more than on 7,1 mln he and they are

24,6 mln ha. And the sowings of cereal's and legume's crops is kept on the level 15 mln ha (61%), but the sowings of sunflower incessantly increase and they are 4,57 mln ha or 19 % from common area of sowing. The area sowing of turnip changes every year, but it reaches 1,2–1,7 mln ha (5–7 %), and the sowing of feed's crops decreased on 9,4 mln ha and its part is only 10,5 %.

In Ukraine the leading scientific institutes for each nature-agricultural region accepted the norms of optimal correlation crops in sowing-changes, and also the terms of return separate crops in sowing-change. Only in steppe's regions the saturating of sunflower in sowing-change is admitted on 10–15 %, and turnip – 5–12 %. The comparison of factual and normative indices of correlation crops testifies about mass nonobservance by agricultural enterprises the scientific-substantiated sowing-change or even their absence. The sowing of tactical crops reduce to soil's exhaustion, to forming little-productive lands, and, at last, to their degradation. Every year the area of these lands increases and now it numbers over 1,4 mln ha. It testifies about ineffective using of lands and absence of their reliable protection in agricultural enterprises.

In the article they are turning out and the changes, which were happened with movable phosphorus' forms in usual black soils on tillage about to virgine land. To give objective mark of state and to install a direction of transformation the modern evolutionary changes of phosphorus' regim of usual black soils – it gives possibility to compare virgine and arable lands for content of movable phosphorus' forms, which determined for different methods over each 5 cm on whole depth of soil's types on the tillage and virgine land.

The source of phosphorus' arriving on virgine land is disappeared plants' parts, and on the tillage they are fertilizers and crop-root's residues. The problem becomes acute by the irreparable losses of phosphorus, which is stipulated by taking out of this element from the soil by the plants, since it accumulation predominates in grain, and not in vegetative mass, which replenishes the deposits of inaccessible for plants elements after the harvesting in the process of microbiological discord. On the tillage the basic phosphorus' mass is separated from the soil together with grain, which is took out from the fields every year.

The basic quantity of phosphorus (0,65–0,85 %) is concentrated in the grain, it almost in three-four times exceeds its content in leaf-stem's mass (0,20–0,28 %). So, the abandoned in the field, whole leaf-stem's mass isn't able fully compensate for the phosphorus, which was took out with corn yield. To that in the soil the negative phosphorus' balance doesn't appear, we need to return in it this important element of mineral feeding together with phosphorus-contentive fertilizers. So the providing soil with phosphorus now can materialize only for expense the applying of phosphorus' fertilizers.

For the last 25 years the quantity of applied phosphorus on 1 ha of sowing area reduced from 40 kg of active substance to 3–4, nitrogen – from 60 to 5–15, potassium – from 35 to 1–2 kg of active substance. In the last ten years the producing of phosphorus' fertilizers in Ukraine sharply reduced, specifically in 2005 it reduced on 22,9 %, it causes to sharp fall of level applying mineral phosphorus' fertilizers. This situation is connected with their high value, which was conditioned by increasing prices on energy bearers and by insufficiency of sources own phosphate's raw material for their producing (tabl. 1).

The one way of solving the problem of phosphorus' feeding is wide using of phosphorytes from local deposits. Ukraine has a considerable quantity of phosphorytes' deposits (Volynska, Izyumsko-Donetska groups of deposits and others), tge deposits of which are numbered to laying of low kembriy, upper whiting and paleogen. In western Polissya it has been already explored the deposits of grainy and zhovnoviy phosphorytes in store of agroore, the deposits of which lie from 10 to 20 m, but sometimes they are nearly to surface. But after low concentration in them P_2O_5 these phosphorytes aren't remaked on superphosphatus and others water-solutive phosphorus' fertilizers, so for producing phosphorus' fertilizers in generally the imported raw material is used.

In the most of cases the Ukrainian phosphorytes contain in their composition 5 % P_2O_5 or 12–15 % phosphoryto-calcium's minerals and phosphates' rocks, so they are needed a realization of their additional concentration, after realization of which it will be substantially grow the cost of phosphorus' fertilizers. In connection of that these phosphorytes are used only on sour soils in Po-

lissya and Carpathians and on weakly-sour soils in forest-steppe zone: in sour medium the weakly-soluble phosphates dissolve easily.

1. The comparative valuation of gross phosphorus' content in basic and accessory production of basic agricultural crops

Agricultural crop	The average phosphorus content in withered substance	
	grain	leaf-stem's mass
Winter wheat	0,85	0,20
Winter rye	0,86	0,25
Corn	0,57	0,30
Spring barley	0,85	0,20
Oats	0,85	0,35
Millet	0,65	0,18
Sorgo	0,67	0,35
Pea	1,0	0,35
Soybean	1,04	0,31
Sunflower	1,39	0,65
Turnip	1,8	0,25

On the soils with neutral reaction of soil's solution the phosphates aren't practically assimilated by plants' roots, and they aren't used practically there. On these soils we need to prefer to water-soluble tucks. Accounting the infringement of prices' parity on agricultural production and fertilizers, the amounts of applying the phosphorus' fertilizers aren't high. In generally they are applying at sowing in small doze P_{10} . Taking into consideration the low natural providing with movable phosphorus' combinations in the most of soils, the sharp fall of effective fertility of soils is observed, the regim of phosphorus' feeding of plants is worses, as result it causes to reduction the yielding of agricultural crops.

The comparative analysis a content of movable phosphorus in these two soil's types persuasively shows their accumulation in upper stratum of soil in compare to disposed deeper. First at all it connected with biological accumulation of phosphorus by root's systems of plants. This biological accumulation passes in result of activity the plants' roots, which for their exudates dissolve the phosphates of calcium and magnium, and transfers them in hidro- and dyhidrophos-phates, and piles up this element of mineral feeding in surface horizons of soil.

The anion PO_4^{3-} into soil is in organical complexes (nucloproteidy, fosfatydy) and in different correlations with cations Ca^{2+} , Mg^{2+} , Fe^{2+} , Fe^{3+} , Al^{3+} . These phosphates in different degree are accessible to plants' roots. The changes of content the common phosphorus in soil on virgine and arable areas are characteristic only to upper (0–10 sm) stratum – 0,164 and 0,148 %. Beginning from the soil's stratum 10–20 sm and deeper at type, its deposits are on the one level. So in our researches the main attention is concentrated on movable phosphorus' forms, which in the most of causes are the limit factor for growth, development of plants and formation yielding of agricultural crops.

The mobilization of phosphorus from heavy-soluble natural combinations happens mainly after action of products metabolism's of microorganizms. The main meaning is in bacteriums, which have potential ability to change the heavy-soluble soil's phosphates in accessible form for plants. Among them the soil's bacteriums *Rhizobium radiobacter* take the important place, which, besides phosphate-mobilizative activity, are able to associative nitrogen-fixing. It's known that one of the factors of solution the heavy-soluble mineral phosphates in souring of soil's solution, and the hydrolize of organophosphates under bacterium's influence is connected with action of specific ferments – the phosphataze. The scientists determined that bacteriums *R. radiobacter* are active producents by acetone's, oils and others organic acids, under the influence of which transferring into soil's solution the weak-soluble phosphates of calcium and magnium has hold. It's determined that the phosphatoze's activity of bacterium is from 0,17 P_2O_5 kmol/ml/he (*R. Radiobacter* 5005) to 2,35 P_2O_5 kmol/ml/he (*R. Radoibacter* 5006). Our researches showed that the highest number of

phosphate-mobilizative bacterium is characterized as upper humus horizon on virgine land (see tabl. 2).

2. The number of phosphato-mobilizative bacteriums in soil's examples, which were choosed in soil's slit on virgine and arable land of usual black soils (outskirts of v. Baykivka Pyatykhatskiv district Dnipropetrovsk region)

The soil's stratums, sm	The phosphate-mobilizative bacterium, mln/g which dissolve	
	mineral phosphates	organophosphates
Tillage		
0–5	1,5 ± 0,1	5,4 ± 0,4
5–10	1,3 ± 0,1	2,3 ± 0,1
10–15	1,3 ± 0,1	2,7 ± 0,2
15–25	2,2 ± 0,2	2,4 ± 0,2
25–35	1,2 ± 0,1	4,5 ± 0,3
The soil's stratums, sm	The phosphate–mobilizative bacterium, mln/g which dissolve	
	mineral phosphates	Organophosphates
35–45	1,4 ± 0,1	1,0 ± 0,0
45–46	0,6 ± 0,1	1,0 ± 0,1
Virgine land		
0–5	6,8 ± 0,3	9,8 ± 0,6
5–10	2,5 ± 0,2	4,7 ± 0,4
10–15	2,2 ± 0,1	2,2 ± 0,2
15–25	1,5 ± 0,1	2,0 ± 0,1
25–35	1,2 ± 0,1	2,5 ± 0,3
35–45	0,8 ± 0,1	1,2 ± 0,1
45–65	1,2 ± 0,2	0,9 ± 0,0

The studying of phosphate's state the usual black soils shows the next: according to facts of normative document of former USSR (the method of Chyrykov), the upper horizons of agro- and biogeocozenes are characterized by high providing with the phosphorus – is 167 and 163 mg P₂O₅/kg of soil (tabl. 3). The analysis of soils, which was done by national standart of Ukraine (the method of Karpinskiy-Zamyatyna), shows that present mark of soil's fertility is erroneous, and these cenozes are characterized only by average providing with phosphorus. It was explained by well-known empiric facts about high effectivity of phosphorus' fertilizers on black soils. The divergence in mark of phosphate's state is explained by the next: the earlier researches it was established that black of heavy-loam's and clay's granulometrical composition on the les' rocks contain the increased or high quantity of apatyto-similar combinations of phosphorus – over 200 mg P₂O₅/kg (fraction Ca-P, method Chang, Jackson) (tabl. 4).

The phosphorus, which contains in these minerals, is directly inaccessible for plants, but it partly extractes by solutions of strong acids, including by 0,5 n acetic acid (method by Chyrykov), just that's causes to substantial increasing the mark of phosphate's state of the soils.

The using of standart of Ukraine shows that real natural content of movable phosphorus in these soils correspondes to so-called level of dynamic balance, that is 0,04–0,06 mg/l.

According to demands the normative documents of Ukraine, the content of movable phosphorus in soils of steppe zone we must to determine by one of the three methods: Karpinskiy-Zamyatyna, Machygina (DSTU 4114) or Olsen (DSTU ISO 11263).

The content of movable phosphorus in researching cenozes of usual black soils is a little higher than level of dynamic balance of phosphate's soil's systems – 0,17–0,19 mg P₂O₅/l on tillage and 0,13–0,14 mg P₂O₅/l in stratum 10 sm on virgin land. For tillage the present increasing is explained by the availability of remained phosphates of fertilizers. So, this soil is little-fertilized.

That concern a virgin land, we can note the next. Thanks to complex of biochemical, chemical, physic-chemical and other processes, which are characterized for upper humus horizon of virgin and tillage soils, their phosphate's systems are characterized by higher quantity of free ener-

gy. Certainly, the main source of this energy, which compensates for output of entropy at biological and chemical processes, is organic substance. The present combinations neutralize a positive stores on surface of clay's minerals, connect an active cations of iron, aluminium and form a bloc of fixing the anions of phosphorus' acid. That's why this horizon of present biogeocozenes is characterized, as a rule, by increased or high providing with the phosphorus.

The phosphate's state of low horizons the both cenozes is practically similar and correspond to the level of dynamic balance. The availability of the higher content of movable phosphorus in separate soil's stratum (0,10–0,12 mg P₂O₅/l) is made for expense the availability of calcium's carbonates. As a result of appearance these combinations the neutral meaning of salt's stretching (pH-5,8) dislocate in the alkalial side, and it increases its extragium ability.

The content of movable phosphorus' forms in soil depends on the much factors, including the level of its moisturing, that is connected with different activity of biota. So, at soil's drying it decreases, and after moisturing there is a tendency to its growth. This regularity very often is observed in dry years, when at the drying of the soil, the phosphorus' availability is reduced because of fast formation of non-soluble complexes of anions (PO₄³⁻, HPO₄²⁻, H₂PO₄⁻) and with cations (CaO, Fe, Al and others) and for expense its inscribing into organic combinations by the microorganisms. That's why the coefficient of phosphorus' using from mineral fertilizers, even at

3. The content of movable phosphorus in different cenozes of usual black soils for facts of acid's and salt's methods

The soil's stratum, sm	The content of movable phosphorus by Chyrykov (mg P ₂ O ₅ /kg soil)		The content of movable phosphorus by Karpinskiy-Zamyatyna (mg P ₂ O ₅ /l)	
	tillage	virgine land	tillage	virgine land
0–5	167	163	0,19	0,14
6–10	167	112	0,18	0,13
11–15	169	92	0,18	0,10
16–20	168	96	0,17	0,09
21–25	172	88	0,14	0,09
26–30	164	83	0,19	0,08
31–35	137	80	0,15	0,04
36–40	112	78	0,11	0,04
41–45	92	77	0,11	0,09
46–50	94	75	0,11	0,09
The soil's stratum, sm	The content of movable phosphorus by Chyrykov (mg P ₂ O ₅ /kg soil)		The content of movable phosphorus by Karpinskiy-Zamyatyna (mg P ₂ O ₅ /l)	
	tillage	virgine land	tillage	virgine land
51–55	107	64	0,10	0,06
56–60	54	79	0,10	0,12
61–65	53	88	0,08	0,10
66–70	59	53	0,07	0,09
71–75	53	58	0,11	0,07
76–80	62	39	0,10	0,07
81–85	56	41	0,10	0,11
86–90	54	36	0,10	0,10
91–95	50	35	0,12	0,08
96–100	51	34	0,12	0,07
101–105	50	34	0,11	0,11
106–110	50	35	0,10	0,11
111–115	50	38	0,13	0,11
116–120	48	38	0,12	0,12
121–125	48	39	0,12	0,12
126–130	48	39	0,11	0,11
131–135	49	39	0,11	0,10
136–140	51	40	0,12	0,10
141–145	52	40	0,12	0,11
146–150	49	41	0,13	0,10

151–155	50	40	0,12	0,10
156–160	53	40	0,12	0,10
161–165	57	40	0,11	0,08
166–170	62	42	0,13	0,08
171–175	73	42	0,13	0,07
176–180	77	44	0,12	0,06
181–185	69	45	0,12	0,06
186–190	73	48	0,13	0,10
191–195	74	52	0,13	0,10
196–200	78	55	0,13	0,09

sufficient its applying, is only 10–20 %, while nitrogen – to 50 %, potassium – to 70 %. The low temperature of soil (<10 °C) evokes the phosphorus' deficiency for plants even at its high content in the gross form. At the low temperature the swamp of soil's solution increases and the intensivity of its absorption from soil's solution by plants' root's system decreases. The increasing of temperature in soil's solution on 1–2 °C causes to increasing of phosphorus' content in soil's solution on 2 %. At deficiency of moisture the phosphorus' assimilation from the soil is complicated. For that to follow the conglomeration of movable phosphorus we made the favourable conditions of moisturing 60 %

4. The phosphathe's state of arable stratum the nonfertilized usual black soils of heavy granulometrical composition in north steppe of Ukraine

Content P ₂ O ₅ by:						
P. gros., mg/kg	Chyrykov, mg/kg	Karpinskiy- Zamyatyna, mg/l	Chang, Jackson			
			P soft, mg/kg	Al-P, mg/kg	Fe-P, mg/kg	Ca-P, mg/kg
1060	107	0,06	4,7	55	78	245
1230	89	0,03	5,0	37	8	250
1330	103	0,05	2,3	42	49	170
1370	115	0,06	3,0	64	12	276
–	126	0,05	5,2	31	72	304
1430	91	0,05	5,5	30	73	358
1550	113	0,06	6,0	62	106	367
–	106	0,04	2,8	50	68	221

from full moisture-capacity and favourable temperature's regim 28,5°C. At these conditions the composting of soil's examples, which were choosed from the different genetic horizons in thermostat was conducted. In soil's examples in 10, 20 and 30 days the determination of movable phosphorus' forms was held by Chyrykov's method, and the level of their mobility was determined by the method of Karpinskiy-Zamyatyna (tabl. 5).

5. The influence of the composting on content P₂O₅ in soil's examples, which were choosed on the virgin land and on old-arable area of field (mg/100g of soil)

Soil's stratums, sm.	The methods of determination P ₂ O ₅ , mg/100g of soil							
	by Chyrykov				by Karpinskiy-Zamyatyna			
	before compos- ting	after 10-days compos- ting	after 20-days compos- ting	after 30-days compos- ting	before compos- ting	after 10-days compos- ting	after 20-days compos- ting	after 30-days compos- ting
the virgin area of field								
0–5	16,3	22,3	22,6	22,0	0,14	0,52	0,40	0,33
6–10	11,2	19,0	22,3	21,7	0,13	0,50	0,29	0,34
11–15	9,2	14,4	20,7	19,2	0,10	0,50	0,26	0,30
16–20	9,6	17,0	19,7	18,8	0,09	0,46	0,23	0,27
21–25	8,8	17,7	19,2	18,4	0,09	0,48	0,24	0,24
26–30	8,3	18,0	18,6	18,0	0,08	0,38	0,22	0,24
the old-arable area of field								

0–5	16,7	22,9	25,9	27,7	0,19	0,58	0,32	0,35
6–10	16,7	18,3	26,7	28,9	0,18	0,56	0,31	0,34
11–15	16,9	22,6	26,2	27,9	0,18	0,50	0,31	0,32
16–20	16,8	22,9	25,9	27,7	0,17	0,62	0,30	0,29
21–25	17,2	23,6	25,5	27,4	0,14	0,54	0,29	0,26
26–30	16,4	24,7	25,3	26,2	0,19	0,52	0,31	0,25

The done researches show that the most intensive accumulation of movable phosphorus' forms was in the first ten days. In the less degree it has been observed in 20 days, and after thirty days of the composting it has been observed the tendency to decreasing content in soil the high-called phosphorus' forms.

That's why, the researches, which were held with the using of modern methods of soil's diagnostic, showed that the real natural providing with phosphorus the usual black soils of the North steppe of Ukraine isn't high, that's limits the getting of high yields of agricultural crops. As a result of this, the present soils in the same way need the applying of phosphorus' fertilizers, as the others soils of Ukraine.

The exact information about trofical state of the soils, first of all about the macroelements of plants' feeding and the dynamics of their fertility, allows, without essential additional expenses, to use the fertilizers more effective, and to increase the yields of agricultural crops and the quality of received production.

The conclusions

1. The usual black soils on the les rocks of heavy granulo-metrical com-position in the North steppe of Ukraine contain the increased quantity of apatytosimilar com-binations. As a result of this, the using of any acid's methods, including the GOST 26204-91 (the method of Chyrykov), causes to the essential artificial increasing a valuation of phosphate's state of the soils (on 40–80 mg P₂O₅/kg of soil).

2. For diagnostic the phosphate's state of these soils, according to the demands of normative documents of Ukraine, we must to use the next standarts: DSTU 4114 (method of Machygin), DSTU 4727 (method of Karpinskiy-Zamyatyna) and DSTU ISO 11263 (method Olseh).

3. The real natural providing with phosphorus the arable stratum of usual black-soils corresponds to limit of low and average providing with this element of plant's feeding, and it is confirmed by the famous empirical facts about the high effectiveness of the phosphorus' fertilizers on these soils.

4. Only the arable stratum of the soils, which contents the remained phosphates of fertilizers, is characterized by the increasing or high providing with phosphorus, and also – the upper humus' horizon of virgin soils. So, to get a high yields of high quality on usual black-soils in north steppe of Ukraine it is necessary to apply not less the phosphorus' fertilizers than in the others soils of the country.

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