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Antropogenous Changes of Dark-Chestnut Soils of the Northern Kazakhstan and Measures for their Improvement

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ABSTRACT

The problem of anthropogenic changes in the agrochemical, chemical and physical properties of dark-chestnut carbonate soils of the Northern Kazakhstan as a result of extensive use in agriculture is considered in the article. It was analyzed the characteristics of degradation processes and their estimation. There was a decrease of humus content, gross forms of nitrogen and phosphorus. The amount of absorbed bases also showed a decrease in direct correlation with the size fraction (<0.001 and 0.01 mm). It was identified and justified the need to develop techniques to restore the potential and effective soil fertility. An analysis of the closest to the target recovery methods of soil humus is given. An objective assessment taking into account the actual organizational and economic, agronomic and technological features and capabilities are shown. The necessity of a comprehensive approach to the restoration of the potential and effective soil fertility with the use of traditional and new approach, a focused management approach soil fertility in relation to the zonal conditions, allowing at the same time to solve two major problems - the restoration of soil fertility, and the optimization of supply, which ensures high efficiency and environmental safety the use of chemicals was justified.

KEYWORDS
Extensive agriculture, degradation, humus mineralization, green manure, restoration of soil fertility

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Introduction

The rapid developments of human activities has led to intense, often devastating impact on the environment (Percival, 2013; Ponomarenko et al., 2016). Due to anthropogenic soil degradation, manifested intensively since the end of the last century, the problem of maintaining, improving and extended fertility reproduction is becoming increasingly important (Tietenberg & Lewis, 2016; Ricca & Guagliardi, 2014). In the documents of the UN environment and development conference it is given the data on the extent of degradation of the soil covering the Earth: extreme degradation – 1%; strong – 15%: moderate – 46% light – 36% of land area. Processes of soil degradation are widespread in both humid and arid zones of the world. According to international organization FAO, about 70% of land area of the globe is presented unproductive, productivity of which is limited by the soil and climate, relief or economic conditions.

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Simultaneously it increases the loss of soil productive in the world. Over the last 50 years, the total area of productive soils decreased by 300 million hectares and quantity of the lost in the result of the processes of dehumification of organic carbon made up 38 billion ton. (Dobrovolskiy, 1985; Anon., 2012).

According to U. Uspanov Kazakh Scientific Research Institute of Soil Science and Agricultural Chemistry, for the period of operation of virgin lands in Kazakhstan from 4,3 billion tons of humus reserves of arable layer were irretrievably lost in the result of mineralization of organic matter, removal with the harvest, wind and water erosion 1,2 billion tons or 28,35% (Akhanov, 1997).

As a result of long and extensive agricultural use, soil fertility of the Northern Kazakhstan tends to a steady decrease (Anon., 1995; Kurishbayev, 1997).

The most in the structure of valuable agricultural land is black and dark-chestnut soils in the Northern Kazakhstan (Chernenok, 2009).

Dry steppe zone of dark chestnut and chestnut soils are the most extensive from all agricultural regions of Kazakhstan. It stretches from the West to the East to 2 400 km in width of 150-200 km, dramatically expand Kazakh hills in the area up to 600 km. The total area of the dry steppe zone is 62,4 million or 22,9% of the territory of the Republic (Chernenok, 1993).

Subzone of moderately dry steppe of dark chestnut soils stretches as wide strip from the Caspian lowlands in the West to the Irtysh plains – in the East. Land area of dark chestnut soils of dry steppe zone of the flat territory makes up 31,2 million or 14,5% of the territory of the Republic. Arable land covers 7,1 million hectares in subzone (Anon., 2012).

High plowed land of the Northern Kazakhstan is characterized for dark chestnut subzone. Plowing the soil is one of the most essential factors of degradation arid ecosystems, leading to changes in the structure of all natural ingredients, in a particular way – soil and vegetation (Kurishbayev, 2006; Tietenberg & Lewis, 2016). Natural vegetation in such case is radically destroyed, which leads to disruption of the natural course of migration and reproduction of elements in the soil profile.

Available material of research on dark chestnut soils of Kazakhstan showed that in a relatively short historical period of exploitation of land, major agrochemical properties have undergone significant changes, (Eleshev & Kucherov, 2007; Kucherov & Turganbayev, 2009). Analysis of the current state of dark chestnut soils requires complex study of human influence on the morphological, agrochemical, physico-chemical and physical properties of soils.

For the scientific basis of rational and highly effective use of dark chestnut soils of the Northern Kazakhstan it requires a deep and comprehensive study of the basic indicators of soil fertility, having a decisive impact on the productive capacity of the soil and crop productivity. In this case, the great theoretical interest and practical importance is the knowledge of patterns of change in the basic properties of dark chestnut soils from long-term development for the further development of activities aimed at increasing the potential and effective soil fertility.

Method

For studies it was selected Vozdvizhenskiy settlement of Tselinograd district of Akmola region, as a typical representative of these soils. Study of agrochemical and physicochemical properties was conducted on 5 sections, laid down in 5 fields. The basis for the placement of cuttings in 2011 served a soil map and direction word for 1986 with the help of which it was measured the geographic coordinates and laying of repeated soil sections in base points of 1986 with known coordinates (Table 1).

Table 1. Arrangement of sections

Field №	*Field №*	*Field area. ha*	*Land. crop*	*Geographic coordinates*
1	5	242	arable land. wheat	51°12.251′n.w.071°05.153′e.l.
2	6	242	arable land. wheat	51°11.343′ n.w.071°04.897′ e.l
3	8	368	arable land. wheat	51°11.507′ n.w.071°08.702′ e.l
4	10	336	arable land. wheat	51°10.941′ n.w.071°03.995′ e.l
5	15	346	arable land. wheat	51°08.257′ n.w.1°10.772′ e.l

Soil samples were selected with tape column by genetic soil horizons. Particular attention was paid to the study of soil indicators most strongly reacting to domestication, and the definition of indicators that can be tracked orientation of soil processes.

Chemical analyzes were conducted by the following parameters:

1. Humus by Tyurin in Simakov's modification, GOST 29269-
2. General nitrogen by Kjeldahl, GOST 26107-84
3. Gross phosphorus by Ginsburg, GOST 26261-84
4. Easy hydrolyzable nitrogen by Tyurin and Kononova
5. Moving phosphorus by Machigin, GOST 26205-91
6. Moving potassium by Machigin, GOST 26205-91
7. Carbon dioxide carbonate with volumetric method, GOST 26424-85
8. Absorbed calcium and magnesium by Tyurin, GOST 26487-859.
9. Absorbed sodium by Antipov-Karataev and Mamayeva with determination on the flame photometer, GOST 26950-86
10. pH of soil suspension with potentiometric method, GOST 26483-85
11. The aqueous extract by Gedroits, GOST 26423-85 – 26428-85
12. The mechanical composition by Kaczynski with soil preparation with pyrophosphate sodium, GOST 12536-79
13. The density of shape by the method of cutting cylinder by Kaczynski (Anon., 1995)

Data, Analysis, and Results

The results of research on dark chestnut carbonate middle powerful light clayish soils revealed significant changes in the physical, physico-chemical and agrochemical properties of the soil as a result of 25 years of human impact on it under extensive farming.

One of the most important indicators of soil fertility is the humus content, the reserves of which largely determine the agrochemical, agro and biological properties of the soil. Humus content depends on soil and climatic conditions, cropping patterns, tillage intensity, quantity of fertilizer and ameliorants. At agricultural use of soil humus continuously mineralized, and the batteries are disposed with the harvest. The greatest losses of humus due to its salinity and erosion processes occur in soil and under row crops (Kurishbayev, 2006).

In the system of extensive agriculture, it has happened significant changes in soil fertility potential. Thus, the content of humus in the period from 1986 to 2011 decreased from 3.32–2.72% to 2.84–2.35%, or an average of 0.42% of absolute index that makes up 14.3% relative losses due to its mineralization (Table 2).

Table 2. Anthropogenic changes of dark chestnut soils fertility

Controlled indicators	*Baseline data of soil sections. 1986*						*Follow-up data of soil sections. 2011*					
	1	2	3	4	5	Average	1	2	3	4	5	Average
Humus content in layer of 0-20 cm.	3.32	2.97	2.79	2.84	2.72	2.93	2.84	2.53	2.45	2.35	2.39	2.51
Deviations %							-0.48	-0.44	-0.34	-0.49	-0.33	-0.42
Content of gross nitrogen in the layer of 0-20 cm.	0.21	0.18	0.16	0.17	0.16	0.18	0.17	0.15	0.12	0.13	0.12	0.14
Deviations %							-0.04	-0.03	-0.04	-0.04	-0.04	-0.04
Content of gross phosphorus in the layer of 0-20 cm.	0.20	0.13	0.12	0.14	0.15	0.15	0.15	0.10	0.10	0.11	0.12	0.12
Deviations %							-0.05	-0.03	-0.02	-0.03	-0.03	-0.03
Light hydrolysable nitrogen in the layer of 0-40 cm. mg/100g of soil	7.06	7.56	6.00	7.55	6.92	7.02	6.59	6.77	5.52	6.45	6.52	6.37
Deviations %							-7.7	-10.5	-8.0	-14.6	-5.8	-9.3
Mobile phosphorus in the layer of 0-20 cm. mg/100 g of soil	1.25	3.20	1.98	2.20	2.70	2.27	1.15	2.17	1.50	1.50	1.91	1.65
Deviations %							-8.00	-32.2	-24.2	-31.8	-29.3	-27.3
Movable potassium in the layer of 0-20 cm. mg/100g of soil	56.6	64.0	50.4	49.2	59.8	56.0	50.5	56.2	48.4	46.5	53.2	51.0
Deviations %							-10.8	-12.2	-4.0	-5.5	-11.0	-8.9

These findings are consistent with previous studies in stationary experiments (Chernenok, 1997), in which over 15 years of extensive use of arable land in the crop rotation system grain steam humus content in dark chestnut soils decreased on 0,32%

Over time, it takes place and significant qualitative changes of humus. Since studies have established that the agricultural use of dark chestnut soils reduces the degree of aromatization of humic acids (Kurishbayev, 1997), which in its turn indicates the predominance in the composition of labile humus matters of fulvic acids have higher solubility and mobility, which increases the decay of soil organic matter. The predominance of the process of mineralization of humus and humus formation entails gradual dehumidification of the soil profile.

Reduction of humus on dark chestnut soils was accompanied and it was decreasing of gross nitrogen content. Thus, in 2011 its number in the layer of 0-20 cm decreased from 0.18 to 0.14% of the absolute indicator or 22%.

With the decline of humus and gross nitrogen it is associated hydrolysable nitrogen reduction to 9.3% (Table 2). It is due to the annual removal of nitrogen during the harvest time.

Extensive use of arable land has led to a decrease in the number of gross phosphorus in the layer of 0-20 cm on average from 0.15 to 0.12%. Losses made up 20%.

The content of available phosphorus in the soil after 25 years has decreased on 28.6%. The sharp decline of phosphorus is explained as removal plants as its transformation into hard shapes.

Potassium decreased slightly, which can be explained by the hydrolysis of potassium-containing minerals, the destruction of their root exudates of plants and the displacement of exchangeable potassium.

In the 0-30 cm layer it is noted decreasing amount of absorbed bases on 9.8%, from 29.6-25.4 mg-eqiv/ 100 g of soil in 1986 to 26.9–24.0 mg-eqiv/ 100 g of soil in 2011 (Table 3).

Table 3. Indicators of physico-chemical and physical properties of dark chestnut soils

Controlled indicators	*Benchmark data of soil sections. 1986*						*Follow-up data of soil sections. 2011*					
	1	2	3	4	5	Average	1	2	3	4	5	Average
The amount of absorption in the layer of 0-30 cm. mg-ekv/100 g of soil	28.0	29.6	27.7	26.7	25.4	27.5	26.9	24.5	24.0	24.3	24.4	24.8
Deviations							-1.1	-5.1	-3.7	-2.4	-1.0	-2.7
The content of $CaCO_3$ in the layer of 0-30 cm. %	3.28	4.40	7.86	4.58	4.60	4.94	3.92	4.52	8.84	5.75	4.93	5.59
Deviations							+0.64	+0.12	+0.98	+1.17	+0.33	+0.65
Fraction of mechanical content <0.001 mm in the layer of 0-30 cm. %	32.2	32.0	30.4	33.8	32.2	32.1	30.8	30.4	29.0	30.2	30.5	30.2
Deviations							-1.4	-1.6	-1.4	-3.6	-1.7	-1.9
Fraction of mechanical content <0.01 mm in the layer of 0-30 cm. %	61.1	62.3	62.4	62.3	60.8	61.8	61.0	61.2	60.2	60.8	60.4	60.7
Deviations							-0.1	-1.1	-2.2	-1.5	-0.4	-1.1
Density of laying in the layer of 0-20 cm. g/cm^3	1.27	1.19	1.29	1.10	1.21	1.21	1.10	1.26	1.33	1.29	1.30	1.26
Deviations							-0.17	+0.07	+0.04	+0.19	+0.09	+0.05

This trend of decreasing of calcium cations, magnesium and sodium including in the sum of absorbed bases is explained as with the decline of organic matter as particle size distribution of relief.

Increasing carbonate content in the layer of 0-30 cm with 3.28–7.86% in 1986 to 3.92–8.84% in 2011 can be explained by the progressive involvement in topsoil richer in carbonates of the underlying soil.

During the period from 1986 to 2011 dark chestnut soils in general remained the same light clayish variety. At the current stage it is indicated a slight decrease in arable horizon of silt fraction on 5.5%, which is less effect on the content of physical clay.

Thus, from the conducted research it is seen that over the 25-year period there was a significant reduction in the effective potential and soil fertility, primarily of humus content, which affected the physical and chemical properties of the soil. This requires the development of measures for the restoration of fertility and the cessation of degradation processes.

Today it is known a quite a number of methods for determining humus balance in soil, taking into account various factors.

The main sources of incoming: organic matter with stubble and root residues of crops (C_r and C_g), manure. The main sources of outcome: humus mineralization for different soil types (K_m), under different agricultural crops (K_k) and the average annual soil erosion (S_e). Calculation of humus balance for different types of crop rotations is proposed to conduct the following formula:

$$T = (V \cdot C_r \cdot C_g) - (H_1 \cdot h \cdot d \cdot K_m \cdot K_k) - (S_e \cdot H_1 \ / \ 100) \qquad (1)$$

Where:

H_1 – original humus content, %;

h – height of the humus horizon, cm;

d – volumetric weight, g/cm^3.

But the disadvantage of the method is that all the standard indicators of the formula are rather conditional, since there is no satisfactory method that accounts for the mass of roots. Thus, in the process of mechanical cleaning considerable number of fine roots is lost, root is not considered litter transforming in the process of growth (Sauerbeck & Johnen, 1977). The value of plant residues humification can be varied widely from 7 to 27% (Fokin, 1983).

It is widespread the method of humus balance in nitrogen removal by plants. I. V. Tyurin (1956) suggested that the removal of 50 kg of nitrogen from the soil by plants leads to mineralization of approximately 1 ton of humus assuming that humus contains 5% of nitrogen. But later it was set that removal of nitrogen from the soil by plants may vary in wide limits depending on the nature of agronomy and meteorological conditions (Shevtsova, 1983).

Welte proposed a different approach to the calculation of the balance of humus using the data on the content of humus mineralization coefficients and coefficients of humification of plant residues (Welte, 1955). These factors are not constant and depend on many conditions and above all hydrothermal regime of soil.

For the calculation of credit entry of humus balance, some scientists take into account organic matter supplied with fertilizers, stubbly and root residues, taking into account the factors of humification, which can vary greatly depending on soil and climatic conditions (Shenyavsky, 1973).

A. M. Lykov for calculating the balance of humus proposed to determine items of expenditure on the removal of nitrogen from the soil by plants, a credit – with the account of humification of plant residues. For the account of granulometric composition it is introduced correction factors (Lykov, 1985).

Removal of nitrogen with harvest (R_{yield}) is determined by multiplying its removal unit (R_N) of production on the estimated yield (Y), nitrogen use a correction factor depending on the mechanical composition (K_m) and the utilization of nitrogen depends on the characteristics of crops (K_c) (Eq. 2).

$$R_{yield} = Y \cdot R_N \cdot K_m \cdot K_c \quad (2)$$

To determine the amount of plant in soil, there is provided a linear regression equation (Eq. 3).

$$Y = 0{,}41 \cdot \text{Yield } (t \,/\, \text{ha}) + 1{,}01 \quad (3)$$

Calculation of nitrogen is carried out taking into account the rate of use of crop residues for 50%. The nitrogen content in plant residues is about 1,5% (Eq. 4).

$$I_N = \cdot\, P_r \cdot N_{re}\, U_N \quad (4)$$

Where:

I_N – nitrogen inputs from crop residues, kg / ha;

P_r – quantity of plant residues, t / ha;

N_{re} – nitrogen content of the crop residues (0.0015 or 0.15%);

U_N – utilization of nitrogen from crop residues (0.5 or 50%).

We subtract from the total nitrogen removal with the harvest of its quantity released to the plants of fertilizers and crop residues, find nitrogen deficiency (D_N) covered by humus mineralization (Eq. 5).

$$D_N = R_{yield} - N_{re} \quad (5)$$

Multiplying the nitrogen deficiency by a factor of 10, determine the amount of the decomposed humus (H_{dec}) during the growing season (Eq. 6).

$$H_{dec} = D_N \cdot 10 \quad (6)$$

The number of newly formed humus (H_{new}) is calculated at a rate of humification (kg) of organic fertilizers and crop residues with the content of carbon (C_C). The average carbon content in dry matter of plant residues is 45% (Eq. 7).

$$H_{new} = NR \cdot C_C \cdot C_g \cdot 10 \quad (7)$$

Humus balance (H_b) is determined by deducting from the amount of newly formed mineralized humus (Eq. 8).

$$H_b = H_{new} - H_{dec} \quad (8)$$

This method is the same can't be considered perfect by virtue of the wide variability of parameters used in the formula, starting with the removal and finishing with utilization of nitrogen from crop residues. As it is shown by the 20-year study of V. G. Chernenok, removal of nitrogen and phosphorus crops on dark chestnut soils of dry steppe zone of the Northern Kazakhstan in conditions of limited moisture varies 3 times, the utilization rate of soil nitrogen in 5, 3 times the phosphorus, and from fertilizers respectively 2.5 for nitrogen and 20 times phosphorus (Chernenok, 1997).

It is offered by V. A. Marchenko a model of the dynamics of humus at different tillage methods. Initial information of this model is gross humus content in the topsoil and the number of plant residues coming into the soil (Marchenko, 1988).

But these methods are unacceptable to solve the problem, since it is impossible to restore the 25-year period a complete history of fields, what crops were cultivated, their productivity, etc. Factors used are relative and do not reflect the zonal features on which they depend.

From all of these the methods the most appropriate to us is the method developed by CINAO (Lykov, 1985), where the calculation is based on a deficit of humus immediate fixation change of humus content for the definite period (Eq. 9).

$$H_{res} = H \cdot H_{ar} \cdot d \quad (9)$$

Where:

H_{res} – humus reserves, t / ha;

H – humus content, %;

H_{ar} – the height of the arable layer, cm;

d – volume weight of arable layer, g / cm^3;

Based on the deficit of humus, the calculation of organic fertilizers to restore the original content of humus is held by the formula 10 with the coefficients of humification.

$$N_{org} = D_h / C_h, \quad (10)$$

Where:

N_{org} – the need for organic fertilizers to ensure the sufficient humus balance, t / ha;

D_h – deficit of humus, t / ha

C_h – humification coefficient of organic fertilizers.

This method was put to us as a basis for calculating the deficit of humus.

In the calculations, the following coefficients of humification for dark chestnut and chestnut soils of dry steppe zone: manure – 0.30, straw – 0.20, green manure (green manure crops) – 0.06 (Sychev, 2000) (Table 4).

To make up for the loss of humus, depending on the state of the field it will be required from 8.0 to 87.3 t / ha of manure or 12.0–131.0 t / ha of chopped straw after the grain harvest. But introduction of the chopped straw crops may only partially compensated shortage of organic matter. It is clear that it is impossible to apply in such amount one of three types of organic fertilizers in the field No. 5. To do this, the manure will need 2-3 years, in the straw, depending on the productivity of the decade. Even more for green manure that is associated with a very high degree of mineralization of organic matter. But given the utilization of elements of organic fertilizers, the process of restoring soil fertility is increased by 3-4 times

Table 4. Loss of humus and the need for organic fertilizers t/ha

Section №	*Field №*	*Humus reserves. 1986*	*Humus reserves. 2011*	*Humus deficit*	*Need of sediments to restore humus losses*		
					manure	straw	leies
1	5	101.2	75.0	26.2	87.3	131.0	436.7
2	6	88.4	79.7	8.7	29.0	43.5	145.0
3	8	93.6	84.7	8.9	29.7	44.5	148.3
4	10	81.2	78.8	2.4	8.0	12.0	40.0
5	15	85.6	80.8	4.8	16.0	24.0	80.0

As calculations show to solve the problem of restoring soil fertility using only organic matter can be at a low deficit of humus, 6-15 fields.

However, when properly used, even in dry conditions fertilizers can increase crop yields by 1.5–2.0 times. In addition to fertilizer there are significant changes in the qualitative composition of humus. So V. G. Chernenok's (1997) stationary experiments, the ratio of fertilizer to humic (C_{ha}) and fulvic (C_{fa}) acids was 2.29 and a phosphorus fertilization ratio rose to 2.75, and the ratio of nitrogenous fertilizers decreased to 1.79–2.16 (Table 5) .

Table 5. Effect of fertilizers on the composition of humus of dark brown soil layer 0-20 cm

Applied	*Humus*	C_{ha}	C_{fa}	C_{ha}/C_{fa}
O	3.67	0.98	0.43	2.29
P_{60}	3.74	1.13	0.47	2.40
P_{120}	3.92	1.21	0.44	2.75
$N_{60}P_{60}$	3.68	1.10	0.51	2.16
$N_{60}P_{120}$	3.64	1.04	0.58	1.79

Given data in Table 5 is the amount of fertilizer is applied once per rotation of crop steam rotation (three times for 15 years)

Shortfall of the deficit of nutrition elements it is often used fertilizer balance calculation methods based on indicators removal of nutrition elements of 1 c of production and utilization rates of the elements from the soil and fertilizers, the Eq. 11.

$$D_f = 100 \cdot (Y \cdot C - 30 \cdot A \cdot a) / \mathrm{C_u} \quad (11)$$

Where:

D_f – dose of fertilizer kg / ha;

Y – grain yield, t / ha;

B – Tap N, P or K 1 n main products based on incidental, kg;

30 – factor for converting the nutrient in the soil mg / 100 g of soil in kg / ha;

A – content in soil nutrient availability, mg / 100 g soil;

a – utilization of nutrients from the soil, %;

C_u – the utilization of nutrients from fertilizers, %.

But the coefficients of nutrients from the soil and fertilizers as well depend on many factors – soil environment, the biological characteristics of the culture, the level of harvest, the number of fertilized nutrients, making them art, climate, etc. (Fedorov, 1952).

Testing of this method in the conditions of the Northern Kazakhstan has convincingly shown that the use of the balance sheet method when calculating the doses of fertilizers in low and unstable wetting is unacceptable due to the high degree of variation of all parameters of its components, Table 6 (Chernenok, 1996).

Table 6. N-P fertilizer is using different criteria in the balance calculation (Benchmark data: planned yield 20 tons; hydrolysable N content in the soil - 4.0 mg; P_2O_5 - 2,0 mg / 100g of soil)

Indicators	*Average criteria of long-term studies (n = 500)*			*Reference data*
	max.	min.	average	
Relocation of 1 c of wheat: N	5.6	1.8	3.4	3.0
P	1.3	0.4	0.7	1.1
*CNU: N	50	10	30	30
P	30	10	20	10
*CFU: N	50	20	35	60
P	9.3	0.4	5	15
Calculated dose: nitrogen	104	120	91	40
	89	500	40	106

*CNU - coefficient of usage of nutrients from soil; CFU - coefficient of usage of nutrients from fertilizers

Depending on the used coefficients, calculation dose varies 3 times in nitrogen and 12 times in phosphorus, while harvest in 20 c per ha is obtained by introducing 30 kg of a.i. nitrogen and 150 of phosphorus.

The method is absolutely inacceptable for rainfed agriculture in the Northern Kazakhstan.

Studies have shown that the concentration of nutrients in plants, their consumption per unit of output, and the availability of nutrients from the soil and fertilizer, depend on many factors: the climatic conditions, the initial content of the batteries, their ratio in the soil, which leads to their instability, high dynamism and unpredictability, but because they can't be used to determine the elements of the deficit and the corresponding calculation of doses of fertilizers.

On the base of many years of research, carried out on dark brown soils of dry steppe zone of the Northern Kazakhstan it is developed fundamentally new approach to the definition of deficiency of nutrients in the soil and calculating doses of mineral fertilizers.

Based on regression analysis determined the quantitative relationship crop productivity with the content of nutrients in the soil and their relation. The optimal levels of elements individually for each of the crops and the proposed formula optimization (12-15) and the calculation of doses of fertilizers, taking into account the requirements of crops to the conditions of soil nutrition and original content and the ratio of elements in the soil (Chernenok, 1993; Chernenok, 2009).

To determine the nitrogen deficiency of nutrients in the soil and fertilizer it needs to use the equation 12

$$N_{kg} / ha = (N_{opt} - N_{fact}) \cdot K \cdot Kf_{hum} \quad (12)$$

Where:

N_{opt} – set the optimum level of nitrate nitrogen for one or another culture, mg / kg soil layer 0-40 cm;

N_{fact} – the actual content $N\text{-}NO_3$ in the layer of 0–40 cm in the spring before planting or on the eve of the fall in this field;

K – equivalent nitrogen fertilizer 7.5 kg/ha to increase the nitrogen content of nitrates of 1 mg / kg of soil in a layer 0–40 cm;

Kf_{hum} – correction factor on moisture which is defined by the formula 13.

O_{fact} – actual rainfall (projected for the agricultural year);

O_{norm} – draft regulations

Precipitation is regulatory constant value = 275 mm. This is the average annual rainfall for the 20-year period for the facilities where the study was conducted. Precipitation actual calculated by the sum of the first 9 months (XV) plus forecast hydromet on VI-VIII months (Chernenok, 1996). In our case PK humidification received 1.1, the mean annual precipitation on the basis of (302 mm) for the dry steppe zone. This approach allows adjusting the dose of nitrogen fertilizers and moisture conditions to a minimum (3%) to reduce possible errors in calculating doses.

In this case, the content of nitrate nitrogen in the soil in the presence of hydrolysable nitrogen indicators may be determined by establishing the correlation ratio of (Chernenok, 1996)

$$N\text{-}NO_3 \text{ mg} = \text{mg} \cdot N \text{ lg} \cdot 0.26.$$

For determination of phosphorus deficiency in soil and determining the need for phosphorus fertilizers it is proposed Eq. 14 (Chernenok, 2009).

$$A_P \text{ (kg/ha)} = (P_{opt} - P_{fact}) \cdot 10, \quad (14)$$

Where:

A_P – rate of application of phosphate fertilizers in the soil;

P_{opt} – optimal content of available phosphorus in the soil layer of 0–20 cm, mg / kg of soil;

P_{fact} – the actual content of available phosphorus in the soil layer of 0–20 cm (mg / kg soil);

10 – the equivalent of phosphorus fertilizers showing how much to add kg phosphate fertilizers to the soil to increase a content of available phosphorus of 1 mg / kg.

The optimum content of available phosphorus in the soil layer of 0–20 cm, mg / kg soil experimentally determined individually for each crop, given its individual characteristics.

So, for spring wheat and barley optimum for phosphorus – 35 mg P_2O_5 / kg of soil, nitrogen 12mg; for oat and buckwheat respectively 30 and 10 and corn

40 mg P_2O_5 / kg of soil, oat and buckwheat – 30 mg P_2O_5 mg / kg of soil; for chickpea – 28 mg P_2O_5 / kg of soil and 12 of nitrogen; soybean 25–26 mg.

In determining the doses of nitrogen fertilizers it is offered to consider provision of crop with phosphorus. Each crop requires not only for a certain amount of nitrogen and phosphorus, but their optimal ratio (ratio of P_2O_5 in the 0–20 cm layer to $N\text{-}NO_3$ content in a layer 0–40 cm) for crops which have been found to lie in the within 2.5–3.0.

Therefore, in the case of deficiency of phosphorus in the soil of nitrogen fertilizer dose should be calculated according to the formula 13:

$$N_{def}. = (1/3\ P_{fact} - N_{fact}) \cdot K \cdot Kf_{hum}. \quad (15)$$

Where: 1/3 P_{fact} means that the amount of nitrogen that is necessary for the actual content of phosphorus. This eliminates the possibility of excess nitrogen that the shortage of phosphorus is not used effectively.

Using the proposed method allows to take into account not only the content of $N\text{-}NO_3$ and phosphorus, but also their relationship that at times reduces wastage of fertilizers and provides a highly cost-effective.

Exchangeable potassium content varies from 465 to 632 mg/kg soil. Potassium fertilizers are not required.

Discussion

On the sidelines of the same with a high humus deficiency, should be an integrated approach using not only organic ingredients, but also mineral fertilizers, as a highly effective and fast-acting factor. It should take into account that at this stage the level of development of the livestock sector can't accumulate any significant number of important organic fertilizer – manure. According to statistics from the Ministry of Agriculture of the Republic of Kazakhstan in 1986 was used 33,200 thousand tons of it. In 2006 – 127,000 tons; in 2013 – 74100 tons of organic fertilizers were used in arable lands in more than 22 million hectares.

Generally, by the opinion of recognized scientists and international practice, the share of fertilizers account for more than 50% of the total increase in output. It is due to the high use of chemicals, many western countries have achieved high performance in the production of agricultural products (Saparov, 2002).

Extremely low level of fertilizer used in Kazakhstan (4.3 kg ai/ha crop) is one of the major reasons for the high humus loss and changes in physical and chemical properties of soils.

Calculation of the fertilizer requirement for the above formulas to optimize the conditions of soil nutrition, ensuring the formation of potentially or maximum possible yield, purposefully manage soil fertility increasing primarily effective fertility, thereby reducing the consumption of humus. By forming a high yield, it will be increased and total biomass by-products, leaving that to the field will be improved and the physical properties due to better wetting, biomass accumulation and decomposition of non-tradable parts of plants.

Mineral fertilizers according to the above formulas, guarantees the highest possible yield at a high cost recovery and environmental safety.

I applying of organic fertilizers, doses of mineral ones should be reduced by the number of elements applied with organic fertilizers (manure, straw or leies), but taking into account affordability index data.

Conclusion

Extensive use of soil leads to its degradation – reduction of humus content and vital elements of nutrition, deterioration of physical and physico-chemical properties of soils.

1. In addressing the problem of restoring soil fertility of the Northern Kazakhstan it requires an integrated approach. In the first stage mineral fertilizers should play an important role for improving the efficiency of soil fertility, reducing the deficit of nutrients and increasing the productivity of crops that simultaneously increase the accumulation of organic biomass residues of non-tradable parts of plants.

2. To determine the deficiency of nutrients and calculation of the fertilizer requirement is necessary to use the formula proposed by optimizing supply (12-15) as the most accurate, exclude patterns in the use of fertilizers, which guarantees their high economic efficiency. The use of organic fertilizers in economically reasonable limits will only accelerate the process of restoring and improving soil fertility, improving the physical-chemical properties of it.

3. As it is seen from the studies, special meliorative measures are not required.

4. Using the proposed methods, we can ensure the restoration of soil fertility and increasing crop productivity in 1.5-2.0 times, as the saturation of soil nutrients.

Disclosure statement

No potential conflict of interest was reported by the authors.

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