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Environmental Aspects and Economic Assessment Chemicalization Agriculture under Agro-Ecosystems.

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ABSTRACT

This article highlights the results of the study of environmental problems such as soil contamination in the application of fertilizers and efficiency of resource-saving technology of soybean cultivation with elements of intensification of agriculture is the optimum rate of fertilizer in increasing the productivity of agro-ecosystems. Results of studying of chemicalixation ecological aspect of agriculture and cultivation effectiveness of resource-saving technology of soy at optimum norms of application of mineral fertilizers for agroecosystem efficiency increase are given in this article. The comparative assessment of reasoning of the nutritious mode of the soil and identification of ecological consequences of application of mineral fertilizers at traditional and resource-saving technology of cultivation of soy is given. The analysis of crop provision with nutrients at various options of using mineral fertilizers is given. The content of active forms of phosphorus and nitrogen on the soil horizonsis is determined by phases of plant development at various options of doses of fertilizers and technologies of soy cultivation. At traditional technology of soy cultivation, options without fertilizers and application of doses of the prolonged use of N60P180K90 according to the recommendation of the "Vit" agrocompany are considered. At resource-saving technology, two options with application of mineral fertilizers in a dose - P60K30 and - N30 P60K30 are also tested. At traditional technology it is revealed that application of the increased norms of N60P180K90 leads to increase of soil impurity level caused by heavy metals and decrease in efficiency of the cultivated soy culture. Value of resource-saving technology in rational use of bioenergetic potential of an agroecosystem is revealed and elements of intensive technology with lower norms of mineral fertilizers for increase of efficiency of soy agroecosystem are chosen. It is proved that mineral fertilizers are one of the main factors of stabilization of soil ecological condition, providing optimizations of the nutritious mode and increase of soy efficiency at resource-saving technology of cultivation in the conditions of irrigation in the southeast of Kazakhstan. Application of evidence-based resource-saving methods with elements of ecologically safe intensive technology allows to quickly maintain stability of agroecosystem

Keywords: Chemicals in agriculture, fertilizers, pollution, environmental aspects, technology

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INTRODUCTION

The rapidly developing processes of industrialization of agriculture are strongly dictated by its effective intensification. That in turn suggests the best science-based methods of cultivation of agriculture. Today the world experience of agricultural development indicates that the use of chemicals in agriculture is one of the main ways of its intensification, the key to improving the productivity of arable land, labor productivity, thus improving the economic situation in the sector of agricultural production (Chernikov et al., 2000; Kenenbayev, 2011; Gilewicz, 2011).

Chemicals used in agriculture are a set of measures, based on the results of agrochemical science and the chemical industry and providing extensive use of chemical means for solving the problem of food security in the country (Rubanov, 2004; Chemisation agriculture). Food security, as it is known, is achieved as a step by step solution of the issue of increasing the harvest of crops, conservation, improving soil fertility and quality of agricultural products (Chernikov et al., 2000; "Agribusiness 2020" RK 2013; Maksakovskii, 2002; Besedin & Sokolova, 2010).

The most efficient way to conserve and enhance soil fertility, increase crop yields and maintain a favorable phytosanitary condition of agroecosystems is the application of chemical fertilizers and pesticides. However, despite the positive effects, there is the negative impact of application of chemicals on the environment in agriculture. These negative changes in the agroecosystem are the result of processes of imbalances and excessive impact on the environment with an inhibitory effect on agrophytocenoses and soil (Gamzikov, 2007; Suleimenova & Raymbekova, 2012; Suleimenova et al., 2013; Suleimenova et al., 2014).

The soil cover is more exposed to contamination, degradation and destruction, as all processes in agro-ecosystems associated with transformation, accumulation and migration of substances in the soil. Soil is a filter of incoming toxins, and the most important factor in their transformation (Chernikov et al., 2000;). When assessing the impact of environmental chemicalization agriculture should take into account changes in soil, groundwater, air and living organisms under the influence of soil application of fertilizers and pesticides ameliorants, and under the influence of growing crops. This leads to a reduction in the quality of products, increase its content of nitrates and pesticide residues (Yulushev, 2005; Besedin, 2010; Fedorov & Yablokov, 1999).

Ultimately, the results of environmental violations in economic lead to losses due to the lower productivity of arable land and lower efficiency of invested funds chemicals in agriculture (Kaledin, et al., 2011; Rubanov, 2004; Tolokonnikov, 2002).

Despite the violation of environmental and economic balance in the agroecosystem, there is widespread use of chemicals without considering environmental factors. That is dictated by purely consumer approach of economic entities with respect to natural resources. In this regard, the need for science-based systematic approach to determine the effectiveness of chemicalization agriculture, taking into account environmental factors becomes very important issue.

In this connection, we justified the environmental aspects of using fertilizers in the cultivation of staple crops - soybeans in a south-east of Kazakhstan. We studied disturbances of agro-ecosystem’s ecological balance and developed the optimum parameters of the elements of resource-saving technology aimed at improving the environment and increasing the efficiency of agriculture chemicalization.

MATERIALS AND METHODS OF RESEARCH

Field of study

Experimental studies were performed in scientific- experimental farm "Agrouniversity"of Kazakh National Agrarian University, located on the plain foothill of Trans-Ili Alatau mountains’ northern slope (height 550-700 m above sea level). It is characterized by extreme continental climate, short but cold winter, a long period of high air temperatures, lots of sunshine during warm seasons, intensive evaporation of moisture, low humidity, with a total lack of atmospheric precipitation (Alisheva, 2006). The experiment was performed on meadow-chestnut soils of heavy mechanical composition, which are typical for foothill zone of the Tien Shan mountain system.

Objects and methods of research

The object of research is a unique soybean culture (cultivar Eureka), short - rotational shift of crops tillage. Field experiments and experimental studies were conducted by conventional classical methods: experiments and observations in compliance to the requirements for performing field experiments by B.A. Dospehov's methods (1985) and according to the methodic guidelines by Boiko A.T. and Karyagin Y.G. «Vita» OJSV (2004).

Under comparative evaluation of technology as a control option in the experiments, we choose to use traditional technology of soybean cultivation in accordance with the recommendations of the "System of Agricultural practices of Almaty region" (2005). Biometric and phenological observations were carried out according to the recommendations of the Institute of field crops and vegetable production, and GOST methods for agricultural crops - growing cereals, legumes and oilseeds (Bechey, 2001; Methods, 1971; Korsakov et al., 1968).

The obtained experimental materials were processed by statistical methods of quantitative variation, analysis of variance by Dospehov (1985) and Novikov A.M., Novikov D.A. (2010).

Eco-analytical studies included mandatory procedures: - the sampling, - preparation of samples for analysis, - measurement of pollutants in the studied samples (GOST 17.4.2.02-83).

Agrochemical studies for determining soil's nutrient regime included several mandatory procedures: - the sampling, - preparation of samples for analysis, - the content determination of mobile forms of N- NO_3 and P_2O_5, mg / kg soil (GOST 17.4.4.02.).

Sampling

Soil sampling was carried out in accordance with normative documents that regulate the sampling, ensuring accuracy and presentability, as well as safety of the determined ingredients (GOST 17.4.3.03-85, ST SEV 4469-84). Soil sampling was performed in plots of field experiment to the depth of the arable layer: 0-20 cm for eco-analytical study and 0-30 cm soil layer for agrochemical study by the section's diagonal. For the analysis the combined sample consisted of five spot samples taken from the same plots by the envelope method. The weight of the combined sample was 1 kg. It was gathered into plastic bags, sometimes into wide glass jars with a tight lid. Selected samples were transported to the laboratory in plastic bags or glass jars.

Sample preparation

For preparing samples for research we used method RD 52.18.286-91 (RD 52.18.286-91). Soil samples were spread on paper or vellum, mechanical impurities (plant debris, stones, etc.) were removed by tweezers, samples were dried at room temperature to air-dry state. Dried samples were ground by using a laboratory mill or manually in a porcelain mortar and completely sieved through a plastic sieve with a mesh size of 1 mm.

Reagents and instruments for determination

Used reagents - nitric acid (specific gravity of 1.42 g / cm^3) of high purity according to GOST 11125, magnesium perchlorate (anhydrone) – by TU 6-09-3800, bi-distilled water - according to GOST 6709 and acetylene - by GOST 5457.

Before analysis we prepared standard solutions necessary for tests and calibration used in atomic absorption determination of metals in soil samples of the State standard samples of complex metal salt solutions. Standard solutions of metal salts were prepared immediately before use.

To determine the content of heavy metals in the soil we used the atomic absorption spectrophotometer Shimadzu AA7000, with hollow cathode lamps made of the elements Fe, Zn, Cu, Pb, K. For the sample preparation we used method RD 52.18.286-91.

The determination of the mobile forms N- NO_3 and P_2O_5, mg / kg of soil was made by photo-electro-colorimeter. The method is based on the extraction of mobile phosphorus compounds from soil by acetic acid concentration mol / L in a ratio of 1:25 to the solution of the soil and the subsequent determination of phosphorous as a blue phosphorous molybdic complex by photo-electro-colorimeter (Spirin & Solovyev, 2014).

The analysis was performed in the accredited laboratory of the Kazakh-Japan Innovation Centre at the Kazakh National Agrarian University (the accreditation certificate 58 ROSS.RU.0001.510312). Studied natural objects and defined compounds are included in the scope of laboratory accreditation.

Reliability of assay results ensured compliance with regulated rules and principles of sampling and analysis. On the stage of the analysis the accuracy of obtained data was guaranteed by the use of analytical equipment that passed the state verification, unified methodological basis, state standard samples, and constant internal laboratory control and periodic external control (once per year).

RESULTS AND DISCUSSION

In determining environmental impacts and economic evaluation of application of chemicals in agriculture specific conditions we studied ways of rational use of bioenergetics potential of agro-ecosystems. In 2008-2015, studies were conducted based on the development of resource-saving technologies of cultivation of major oilseeds (soybeans, rapeseed) in a south-east of the Republic of Kazakhstan. An alternative technology includes minimum tillage with elements of intensive technology as the optimal rate of fertilizers and herbicides, taking into account the environmental safety of their use. To justify the environmental dimension of agriculture chemicalization we studied soil pollution with heavy metals under elevated norms of using fertilizers and resource-efficiency cultivation technology with elements of intensive technology as the optimal rate of fertilizer in increasing the productivity and stabilization of agro-ecosystems' ecological situation.

Ecological aspects of fertilizers' application.

According to domestic and foreign researches, increase of crop yields directly depends on use of fertilizers. The correlation coefficients for the main arable crops are the following: winter wheat - 0.79, corn - soybeans and 0.72 - 0.65, which indicates the high positive close connection (Environmental Protection Agency, 2001; Myneev & Bolysheva, 2005; Grant, et al., 2001).

With low fertilizer use, and vice versa in the case of excess of applications, there are environmental problems with a concomitant deterioration in the economic situation of the local and global. In case of imbalance of nutrients in the soil plants reduce its productivity and crop quality. Similarly actions appear redundant rules apply fertilizer.

Fertilizers applied to soil enter into complex interactions with it and their fate depends on its chemical and physical properties. The soil, as a component of the biosphere is rather specific, since it stands as a buffer that controls the transfer of chemical elements and compounds.

Nitrogen fertilizers in the interaction with the soil are significantly different from phosphate and potash. The process of transformation of nitrogen fertilizer in the soil is complex and multiform. Part of the nitrogen fertilizer during the first days after application are consumed by plants, however, the basic amount (60-70%) is involved in two cycles total: small (relatively autonomous and relatively closed) and large (open) cycle. Ammonia forms of nitrogen are absorbed by the soil, but after nitrification acquire properties of nitrate fertilizers. Partially ammonia can be absorbed by the soil in a non-exchange way. Non-exchange, fixed ammonium is available for plants in a small degree. Nitrate forms of nitrogen are not absorbed by the soil, so they can easily be washed away by precipitation and irrigation waters. Under the influence of nitrogen fertilizers organic compounds will faster undergo soil salinity, turning into forms readily available to plants (Grant, et al., 2001; Karpova, 2006).

The disadvantage of many of fertilizers can be attributed to the presence of heavy metals (cadmium, lead, nickel, etc.). Heavy metals in mineral fertilizers are natural impurities contained in agro-ores. Phosphorus and complex fertilizers are the most contaminated with heavy metals. Injected into soil soluble phosphorus fertilizers are largely absorbed by soil, thus becoming less accessible for plants, and undergoes various transformations. Numerous researchers have shown that scientifically justified use of mineral fertilizers is not a factor of environmental pollution (Suleimenova & Ramazanova, 2012; Zubkova, 2004; Chernih, et al., 2003).
In the region of our research, cropping of agricultural plants was conducted with intensive technology, which used higher doses of mineral fertilizers. A striking example can be $N_{60}P_{180}K_{90}$ recommended rates of mineral fertilizers for crops of soybeans at one of the largest agricultural enterprises - JSC "Vita" located on the south-east of Kazakhstan and engaged in the cultivation of valuable leguminous, oil-bearing crop.

During the comparative assessment of the studied doses of mineral fertilizers, there were used ammonium sulfate, superphosphate and muriate of potash. Ammonium sulfate ($(NH_4)_2SO_4$) - average salt of sulfuric acid contains up to 21% nitrogen and 24% sulfur. From the entered norm of fertilizers plants assimilate ammonium sulfate cation NH_4 + much more intense than the anion SO_4 - as the nitrogen is needed for the plants in larger amounts than sulfur. This process is accompanied by the destruction of the basic compounds contained in soil, which increases the acidity, especially with long-term use of ammonium sulfate at the same sites. Thus, ammonium sulphate is a representative of physiologically acidic fertilizers. In the context of our research meadow-chestnut soil has sufficiently alkaline base, so ammonium sulfate, which has an acidic medium, is considered as the most optimal type of nitrogen fertilizers.

Superphosphate ($Ca(H_2PO_4)_2$) is a highly effective granular phosphorus fertilizer. It is made from apatite concentrate, sulfuric and phosphoric acid and ammonia. The heavy metals are contained in the following ranges: lead (Pb) not more than 20 mg / kg, cadmium (Cd) - not more than 0,5 mg \ kg, arsenic (As) not more than 2 mg \ kg, chromium (Cr^{6+}) - not more than 6 mg \ kg. It is well known that in the year of fertilizer application plants use about 30-50%, the rest remains in the soil as the aftereffect of fertilizers. It is therefore necessary to monitor the levels of heavy metals.

Given the above, to support the environmental aspect of agriculture chemicalization we studied soil pollution with heavy metals under use of mineral fertilizers on the context of traditional and resource-saving technologies of soybean cultivation:

1. context - Traditional technology of soybean cultivation: for comparative assessment we studied 1st control case - without fertilizer and 2nd case with use of $N_{60}P_{180}K_{90}$ - the recommended dose for the area of research.
2. context - Resource saving technology of soybean cultivation with mineral fertilizers in two cases: 3rd case –application of $R_{60}K_{30}$ and 4th case – full use of $N_{30}P_{60}K_{30}$

According to the research content of heavy metals in the 0-20 cm of soil layer was different in exploring options (Table 1).

Table 1 - Soil contamination by heavy metals under use of mineral fertilizers, depending on the technology of soybean cultivation (mg / kg)

№	Cases of using mineral fertilizers	Heavy metals, mg/kg				
		Cr	Pb	Zn	Cu	Cd
1st context – traditional technology						
1	Without fertilizers	0,61	0,57	1,13	0,41	0,35
2	$N_{60}P_{180}K_{90}$	5,29	4,83	10,91	3,2	8,6
2nd context - resource saving technology						
3	$P_{60}K_{30}$	0,74	1,29	1,38	0,69	1,28
4	$N_{30}P_{60}K_{30}$	0,81	1,61	2,54	0,72	1,82
MAC, mg/kg		6,0	6,0	23,0	3,0	20,0

The content of heavy metals in the cases of field experiment indicates that on the context of traditional technology of soybean cultivation without mineral fertilizers the soil is low with almost all kinds of heavy metals. Especially low marked is cadmium – 0,35 mg/ kg and copper – 0,41 mg / kg, which is respectively

57 and 7 times lower than MAC level (20,0 and 3,0 mg / kg). The content of the following heavy metals such as Cr, Pb, Zn in the meadow-chestnut soil does not exceed the threshold of permissible concentration (MAC).

The results of the study allowed us to establish that long-term use of high doses of mineral fertilizers for soybean, the amount of heavy metals in the soil root zone significantly increases. Application of mineral fertilizers in the dose $N_{60}P_{180}K_{90}$ - recommended for the research area, gave the following results: cadmium in the soil amounted to 8,6 g / kg, chromium, 5,29 g / kg, lead – 4,83 g / kg, zinc – 10,9 g / and copper kg – 3,2 g / kg. It has been revealed that soil contamination by copper (Cu) is high. Its content increased from 0,41 to 3,2 mg / kg of soil, which is above the threshold of the allowable limit, the MPC of which is only 3,0 mg / kg of soil and soil contamination by copper is subject to high dangerous classes.

According to the literature, the degree of danger caused by heavy metals is divided into three classes, the first of which relates to highly hazardous substances. It contains Pb, Zn, Cu, As, Se, F, Hg. Second, moderately dangerous classes are B, Co, Ni, Mo, Cu, Cr, and the third (low hazard) - Ba, V, W, Mn, Sr (Mineev & Bolisheva, 2005; . Grant.и др, 2011; Suleimenova & Ramazanova, 2012; Zubkova, 2004; Ilin, 2004).

According to this classification applying high dose of $N_{60}P_{180}K_{90}$ into meadow-chestnut soil gives the content of lead (Pb) - 4,83 mg / kg of chromium (Cr) - 5,29 mg / kg, also it shows high degree of contamination by cadmium (Cd) – 8,6 mg / kg and zinc (Zn) – as moderately hazardous degree of contamination.

Thus, the content of heavy metals in the soil in conventional technology is formed in descending order: Zn >Cr >Pb> Cu> Cd. A different picture emerges from applying mineral fertilizers with a rather exaggerated doses ($N_{60}P_{180}K_{90}$), where the number of heavy metals contents looks as follows: Zn >Cd >Cr >Pb > Cu.

Severity level of heavy metals with appliance of high doses of mineral fertilizers can be described as follows. Number of cadmium (Cd) is increased from low to medium; Lead (Pb) and chromium (Cr) - moderate to high; Copper (Cu) - low to high; and zinc (Zn) is low to medium level of soil contamination.

Therefore, elements such as lead and copper being hazardous and cadmium as moderately hazardous heavy metals with use of fertilizers the level of soil contamination from weak to moderate and very high, which should be considered in the intensification of agriculture and increasing the amount of applied fertilizer.

Given the above, we studied the application rates of fertilizers ($R_{60}K_{30}$ and $N_{30}R_{60}K_{30}$) on the context of resource-saving technologies of soybean cultivation to stabilize the environmental situation of agro-ecosystems. Results, of using $R_{60}K_{30}$ and a complete set of mineral fertilizers - $N_{30}R_{60}K_{30}$ with resource-saving technology, show that the greatest number of Zn and Cd is observed in these cases. Comparatively highest content of Zn – 1,38-2,54 mg / kg in applications of fertilizers ($R_{60}K_{30}$ and $N_{30}R_{60}K_{30}$) is far below the maximum permissible concentration (ie, 9,7 and 6,5 times). In these cases, the Cd content was excessive and is 1,8 and 1,82 mg / kg, which is also less than MAC in 15,7 and 10,9 times. It should be noted that the content of mobile forms of heavy metals in the soil is dynamic in time and does not cause a risk of soil contamination by heavy metals.

Thus, under resource-saving technology environmental conditions of soil for cultivation of soybeans is optimized, where the content of heavy metals is much lower than MAC for Cr 8,1-7,4 times, Pb - 4,6-3,7 times, Zn - 16,7-9,0 times, Cu - 4,3-4,2 and Cd - 15,6-10,9 times respectively. The obtained results show that resource-saving technology under application of mineral fertilizers in the dose $R_{60}K_{30}$ and $N_{30}R_{60}K_{30}$ provides an environmentally safe ecosystem for soybean cultivation. That's why its scientifically justified that doses of mineral fertilizers for soybean cultivation are $R_{60}K_{30}$ and $N_{30}R_{60}K_{30}$ which don't accumulate heavy metals in the topsoil with the subsequent improvement in the nutrient regime of soil and increase of crop productivity.

Resource saving technology of soybean cultivation with elements of agriculture intensification

Soybean has specific growth pattern characterized by uneven consumption of nutrients during the phases of development. Creating greater vegetative mass and forming seeds rich in fat and protein, soy needs intensive mineral nutrition. According to many researchers' generalized data formation of 1 quintal of soybean grain requires on average of 8-10 kg of nitrogen, phosphorus and 2-35 kg 3-4 kg of potassium (Karpov, 2006;

Shernih, et al., 2003). The critical period in regard to nitrogen is the period from the budding phase before flowering, when there is an increased growth of the vegetative mass. Soybean plants before flowering consume potassium 1,5 times more than nitrogen and 1,8 times more than phosphorous. Given the specificity of the nutrient regime of soy, it's necessary to use a differentiated approach in determining optimum fertilizer rates, taking into account the biological characteristics of culture. A characteristic feature of soybean is the ability of soybean plants to consume nitrogen via autotrophic ways by means of symbiosis with nitrogen-fixing root nodule bacteria rhizobia. In the absence of rhizobia in soils soybean infestation by these bacteria does not occur and symbiotic process does not function. Symbiotrophic process requires for normal functioning seed treatment by rhizobacteria, that is why we studied case of inoculation through use of bacterial fertilizer-nitragin before sowing.

To justify the nutrient status of the soil and to identify the environmental impact of fertilizers at resource-saving technologies and traditional cultivation of soybeans, we performed a comparative evaluation of three cases – without fertilizers, with nitragin and with three doses of mineral fertilizers ($N_{60}P_{180}K_{90}$, $P_{60}K_{30}$ и $N_{30}P_{60}K_{30}$). The obtained results of the dynamics of mobile forms of nutrients for periods of growth and development of soybean show that with the conventional technology in budding phase content of nitrate nitrogen($N\text{-}NO_3$) in the root layer of soil is 11,3 mg / kg, which is estimated as average and value of Phosphorous (P_2O_5) is at low level (15,2 mg / kg soil) which can be seen below (Table 2).

Table 2 - Effect of mineral fertilizers on soil nutrient values (average for 2012-2014)

№	Technology of cultivation	Dose of fertilizers	Content of mobile form in root layer (0-30 cm) of soil, mg/kg soil			
			$N\text{-}NO_3$		P_2O_5	
			Bud formation phase	Before harvest	Bud formation phase	Before harvest
1	Traditional	Without fertilizers	11,3	6,5	15,2	9,4
2		Nitragin	12,7	10,1	14,6	9,7
3		$N_{60}P_{180}K_{90}$	24,9	15,3	19,8	12,5
4	Resource saving	Nitragin	14,8	12,6	15,9	10,2
5		$P_{60}K_{30}$	18,6	12,1	18,7	14,6
6		$N_{30}P_{60}K_{30}$	26,3	16,7	20,6	13,8

Under resource-saving technologies the optimum nutrient status of the soil is formed. In the bud formation phase of soybeans in 0-30 cm of soil under applying fertilizer in dose $N_{30}P_{60}K_{30}$ there is a largest number of mobile forms of nitrate nitrogen – 26,3 mg / kg soil (Figure 1).

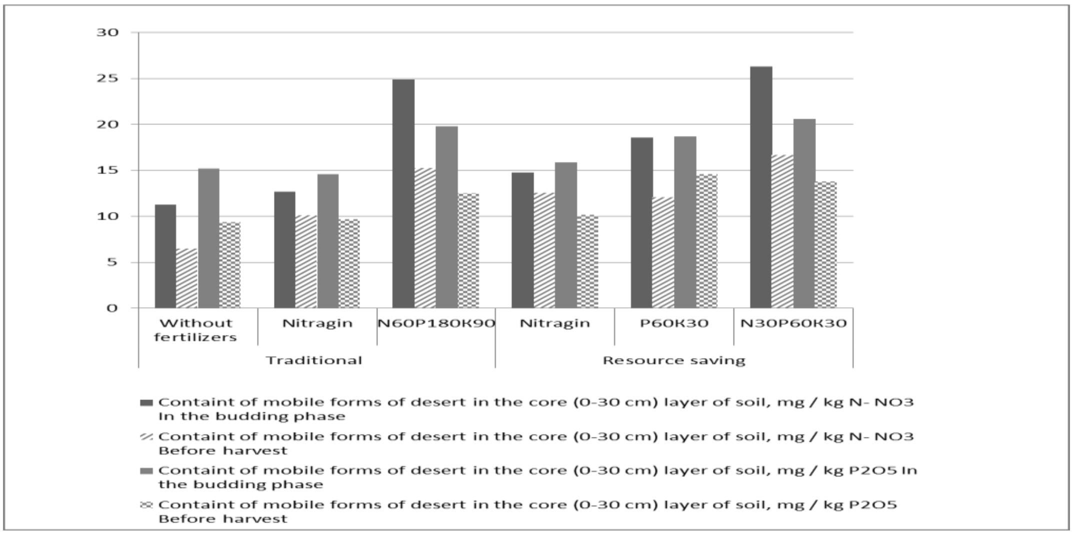

Figure 1- Dynamics of mobile forms of nutrients of the soil, depending on the technology of cultivation of soya farming under application of chemicals

It should be noted that in the same period when applying $R_{60}K_{30}$ the content of $N\text{-}NO_3$ is reduced to 18,6 mg / kg and in the case where the seeds of soybean were treated with nitragin – 14,8 mg / kg soil, but the level of nitrogen content in soil remains average. This pattern is due to the result of nitrification process weakening under the influence of minimizing tillage under resource-saving technology, when most of the organic mass remains in the topsoil.

In the traditional technology of cultivation of soybeans there's a decrease of nitrate nitrogen (6.5 to 10.1 mg / kg) during the harvest and therefore, the nitrogen value is assessed as very low, regardless of tillage system.

The maximum content of mobile forms of P_2O_5, was also in cases of resource-saving technologies. When applying dose of fertilizers $R_{60}K_{30}$ and $N_{30}R_{60}K_{30}$, mobile forms of phosphorus on the development phases show values from 18,7 to 14,6 mg / kg and from 20,6 to 13,8 mg / kg, which is 34,9-% and 28,3 % higher than in the control case with conventional technology of soybean cultivation. Soybean responds well to usage of phosphate fertilizers, especially in context of low levels of available phosphorus in the soil, such as in our case studies.

Analysis of the dynamics of nutrient's mobile forms in soil, depending on the technology of cultivation with agriculture's chemicalization in the period of soybean vegetation leads to conclusion that optimizing nutrient status of the soil has a great impact on the productivity of the culture.

Under conventional technology without fertilizers average soybean yield in control is only 18,9 c/ha. At the same context treatment, before sowing, of soybean seeds by nitragin increases this indicator. This case with nitragin provides a yield increase of soybean from 2,7 to 3,1 c/ha, depending on the technology of cultivation (Table 3).

Table 3 - Soybean yields under usage of mineral fertilizers depending upon technology of soybean cultivation, centner / hectare

№	Technology of cultivation	Appliance of fertilizers	Harvest values per year, c/ha			Average harvest, c/ha	Yield	
			2012r	2013	2014		c/ha	%
1	Traditional	Without fertilizers	19,5	18,1	19,1	18,9	-	-
2		Nitragine	22,1	20,9	21,8	21,6	2,7	14,2
3		$N_{60}P_{180}K_{90}$	24,0	25,4	25,6	25,0	6,1	32,2
4	Resource saving	Nitragine	21,8	20,4	23,8	22,0	3,1	16,4
5		$P_{60}K_{30}$	25,1	25,8	26,2	25,7	6,8	35,9
6		$N_{30}P_{60}K_{30}$	27,1	26,8	28,5	27,3	8,4	44,4
	HCP_{05}, c/ha =		1,74	2,22	1,35			
	S_x, % =		2,47	3,14	1,81			

Using phosphorus fertilizers under resource-saving technology in context of soybean seed treatment by nitragin increases yield from 24,5% to 28,5%. Application of nitragin has positive effect on symbiotic activity, increases the number and weight of nodules on the roots of soybean plants that improve nitrogen nutrition of crops. Therefore, in context and under joint introduction of phosphorus-potassium fertilizer ($R_{60}K_{30}$) soybean yield increases to 25,7 c/ha, i.e. by 35,9%, providing yield increase – 6,8 c/ha. Full usage of fertilizers ($N_{30}R_{60}K_{30}$) under the studied resource-saving technology increases soybean yield to 27,3 c/ha and provides additional yield to 8,4 c/ha. Comparative evaluation of the level of responsiveness of the soybean for level of mineral nutrition has shown that due to physiological characteristics, soybean clearly responds to changes in nutrient status of the soil.

Excessive doses under conventional technology in context of seed inoculation provides a yield of only 3,4 c/ha, while in case of resource-saving technologies, this difference amounts to 5,3 c/ha, which is 1.6 times higher.

Thus, it is proved that mineral fertilizers are among major factors in stabilizing ecological condition of the soil, which increases productivity of soybean plants in the resource-saving technologies of cultivation under irrigation conditions in the southeast of Kazakhstan. Applied science-based techniques of resource-saving environmentally sound technologies with elements of intensification allow to react fast to changes of agro-ecosystem.

CONCLUSION

Determined optimal standards of fertilizer allow to reveal the hidden forms of phytocenosis' environmental disruptions, which occur under the conventional technology of soybean cultivation with long-term use inflated standards of $N_{60}R_{180}K_{90}$.

It is revealed that prolonged use of excessive norms of $N_{60}R_{180}K_{90}$ cause destabilization of agro-ecosystems, where soil is contaminated with heavy metals, the growth and development of plants is hampered and the productivity of arable crops - soybeans is reduced.

As a result of studying the effect of resource-saving technology of soy with elements of agriculture's intensification, there have been determined the optimal rates of mineral fertilizers in the dose of $N_{30}R_{60}$ $N_{30}R_{60}K_{30}$ that create sustainable agrophytocenoses, increase the productivity of agro-ecosystems, biogeochemical cycles fitting in biological cycle of resources.

It is proved that the determined optimal standards for mineral fertilizers ($N_{30}R_{60}$ and $N_{30}R_{60}K_{30}$) are rational parameters for elements under resource-saving technology, aimed at improving the environment and increasing the efficiency of agricultural chemicalization.

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