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ENVIRONMENTAL AND ECONOMIC PROBLEMS OF AGRO-ECOSYSTEM UNER AGRICULTURAL INTENSIFICATION IN CONDITIONS OF SOUTHEASTERN KAZAKHSTAN

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Abstract. *This article suggests solutions to environmental problems of agro-ecosystem under agricultural intensification, the need to optimize the structure of agro-ecosystem by increasing the portion of highly profitable culture with a good amino acid and protein composition, soybean in particular, improvement of crop rotation with increase of environmentally profitable crops' portion, that help to restore and improve soil fertility .*

Key words: *ecology, agro-ecosystem, soybean, intensification, fertilizers, agriculture, soil fertility.*

Introduction. Among branches of social production agriculture has the greatest impact on biosphere's resources than in any other activity. Any work in agriculture is essentially the use of nature, our natural environment for human needs. This production cycle constantly uses earth, water, plant, animal, and energy resources of ecosystem, having greater impact on nature than any other industry [1].

Agriculture should be seen as a huge, permanently acting mechanism that cultivates living natural resources. Therefore, in terms of agricultural production use of natural resources especially land use should be combined with measures to protect it, taking into account possible changes in agro-ecosystem [2].

At the present time on our planet land resources take about 149 million km^2 (29.2 % of total surface of the Earth). Arable land and perennial plantings occupy about 15 million km^2 (10 % of the land), the hayfields and pastures - 37.4 million km^2 (25%). The total area of land usable for tillage is assessed in different ways:

from 25 to 32 million km^2. Arable land in Russia takes 12.9 million hectares. And in our republic according to Ministry of Agriculture the total sown area of crops in 2012 was 21.5 million hectares [3].

These resources must provide population with food. Virtually all agricultural land of the republic is located in areas of risky agriculture, and large areas are in arid areas.

In recent years the area of agricultural land has shrunk. The main reasons for reduction of farmland area are degradation of soil and water resources in the agricultural regions of the world, as well as soil salinization in areas with irrigated agriculture [3,4].

Under functioning agricultural complex the soil is subjected to constant mechanical (under tillage) and chemical (use of fertilizers, pesticides and heavy metals, etc.) influence. With increasing intensification of agriculture there is a significant increase in energy that penetrates soil. For example: energy costs (GJ/ha per year) are 2-5 in primitive natural housekeeping, 6-11 in traditional agriculture, 12-15 in intensive agriculture , 15-20 in highly intensive agriculture. The problems caused by anthropogenic influence arise upon reaching energy costs over 15 GJ/ha per year.

The soil is the main resource of production in agricultural sector. The crops cultivation removes from fields primary (grain, root crops, vegetables, etc.) and incidental harvest (straw , leaves, tops , etc.). At the same time partially or fully it breaks the biological cycle of substances, disturbs soil's ability of self-regulation and reduces soil fertility. Even a partial loss of humus does not give soil an opportunity to perform fully its ecological functions and leads to soil degeneration, i.e. degrade of soil properties. The highest degree of soil degradation is observed in agro-ecosystems due to the violation of the species diversity in plant communities that occur in natural ecosystems. If in natural ecosystems biomass of phytocenosis remains in field, in case of agro-ecosystems, as mentioned above, they are removed without cycle of natural regeneration of soil fertility elements [5].

In addressing these issues the intensification of agriculture is the most important direction with wide use of fertilizers to optimize nutrient regime and use of pesticides for optimization of soil’s phytosanitary condition. But, in turn, environmental problem arises when chemicals are used in agriculture. In long-term, systematic use of chemicals in agriculture gives a real possibility of residues accumulation primarily in soil and also in agricultural production.

Therefore, in this article we aim to suggest the solution of these problems in specific soil and climatic conditions, the need to optimize the structure of agro-ecosystem by increasing the portion of highly profitable crops with good composition of amino acids and proteins, improvement of crop rotation with increase of environmentally profitable crops’ portion, that help to restore and improve soil fertility.

Material and methods of research.

Objects of research are oilseeds, weeds. Experimental studies were conducted by conventional classical techniques: field experiments and experimental observations. Field experiments under short rotation tillage were performed in "Agrouniversity" and "Turgen" farmholds in conditions of southeastern Kazakhstan.

Results and Discussions.

With the intensification of agriculture in conditions of southeastern Kazakhstan in order to address ecological and economic problems of agro-ecosystem we have studied the techniques of improving soil fertility and ecology of agriculture. We considered non-traditional methods of reproduction and improvement of soil fertility, aimed for using biological features of legumes such as soybean. Soybean enriches the soil with nitrogen being in symbiosis with rhizobia, (Table).

Table - Effect of biological characteristics of soybean and fertilizers on the content of mobile forms of nutrients in meadow-brown soil

Studied cases – norms of fertilizers	Soil layer, cm	Content of mobile forms N- NO_3	
		in ramification phase	before harvest
Without fertilizers	0-20	14,9	7,1
	20-40	8,8	6,9
$P_{60}K_{30}$	0-20	19,7	11,1
	20-40	9,6	13,8
$N_{30}P_{60}K_{30}$	0-20	28,3	18,9
	20-40	22,9	12,8

The obtained results of dynamics of nutrients' mobile forms by periods of growth and development of soybean show that soybean's stimulating ability activates biological properties of soil microflora. It means that nodule bacteria in soybean roots in symbiosis increase the content of mobile forms of nitrogen (N-NO_3) in top layer of soil (0-20cm).

In studied cases without fertilizers the amount of N-NO_3 was 14,9 mg/kg of soil, with fertilizers $P_{60}K_{30}$ – 19,7 mg/kg and $N_{30}P_{60}K_{30}$– 28,3 mg/kg of soil in phase. Of this amount, the content of nitrate nitrogen is used for forming soybean crop and by the end of vegetation season their content is reduced to 7.1 and 18.9 mg / kg of soil, which shows positive influence of nodule bacteria before harvest. On average, an optimum nitrogen nutrient status of soil takes place in the top layer (0-40cm) sufficient enough for cultivated and harvested crop with accumulation of remaining nutrients in soil.

Also after soybean harvesting large amount of organic substances i.e. root residues remain in soil which means there's an inexhaustible, constantly renewable source of organic matter. After harvesting soybean 70-80 kg / ha of assimilable nitrogen remain in soil, which equates to 2-3 centners of mineral nitrogen fertilizers or 30-40 tons of manure.

Also, we have defined the soybean place in crops rotation as agro-technique that provides evidence-based accommodation, improvement of soil fertility and productivity. In this case, due to the biological features of previous crops cultures there's no need for additional financial costs, also the structure of agrophytocenosis gets optimized with decreasing amounts of weed.

Depending on the growing conditions of preceding crop species composition and quantity of weed component in agrophytocenosis differs greatly. Infestation of soybean under crop rotation tillage by perennial and non-perennial weeds was less after previous good cultures compared to permanent crops. It should be noted that depending on the precursors soybean infestation is determined by two main factors: first, the ability of culture to suppress weeds, i.e. competitiveness; secondly, technology features of its cultivation. Under the conditions of irrigated zone soybean yields on the permanent crops is 21.7 centners / ha, in case of cultivating soybean after optimal predecessor - winter wheat- the productivity increased to 28.8 centners / ha, and after corn to 27.2 centners / ha, where growth of soy yield was 5.5-7.1 centners/ ha.

Thus, improvement of crops rotations with increase of the share of environmentally beneficial legumes such as soybean provides science-based placement, improvement of soil fertility and productivity. Since it requires no additional financial costs due to biological features of previous crop cultures, the structure of agro-ecosystem is optimized with decreasing amounts of weed.

Under agro-ecosystems intensification the main preference is given towards ecological justification of soil conditions because soil fertility factors change if certain technology of cultivation is used. Under the influence of anthropogenic factors (fertilization, tillage, etc.) there is a change of soil structure, pore space and its overall composition.

Soil structure deteriorates and aggregate composition worsens when fertilizer and tillage are applied. Observation of changes in structural soil composition showed that the main moldboard tillage has a significant impact on the aggregate composition of the soil, spraying its structure. On the other hand soil conserving flat- shearing tillage improves soil's aggregate composition. Loose soil is just as harmful to the crops as over-compacted soil, and its optimal value creates the best conditions for plant life.

According to I.B. Revut "... density, or constitution of soil directly influences the growth and productivity of plants, so it can be considered as an element of soil fertility". Structure largely determines the density of soil composition, its porosity, and therefore can regulate the conditions of water-air regime of crops.

In our studies, the volumetric mass of 0-20cm arable soil layer on soybean crops ranged from 1.21-1.27 g/cm^3, where large deviations were not observed. However, it should be noted that there are some differences between crop rotation fields, such as: a soybean crop in comparison with other cultures has lesser value of volumetric mass - 1.20 g/cm^3.

Compared with the original value of soil density on fertilized variants of soybean crops the density is somewhat reduced with alternation of crops during 3 years, which is most notably in variants with cultures before soybean when density varied between 1.18 g/cm^3 and 1.20 g/cm^3. This value increases with depth. The pattern which has been noted in a year of starting the experiment remains the same, which means that the most optimal value of volumetric mass was given by soybean culture (1.18 g/cm^3). This is probably due to the biological features of this culture and the value of the accumulation of root and crop residues that bind dispersed particles into agronomic valuable units.

So in order to restore elements and improve soil fertility in specific conditions of soil and climate under the agricultural intensification the prerequisite is to optimize the structure of the agro-ecosystem with increasing the portion of environmentally beneficial culture and applying optimal doses of mineral fertilizers.

Conclusions.

The obtained results of dynamics of nutrients' mobile forms by periods of growth and development of soybean show that soybean's stimulating ability activates biological properties of soil microflora. It means that nodule bacteria in soybean roots in symbiosis increase the content of mobile forms of nitrogen (N-NO_3) in top 0-20cm layer of soil from 14.9 mg / kg to 19.7 mg / kg of soil without fertilizer, 19,7 mg/kg with fertilizers $P_{60}K_{30}$ –and 28,3 mg/kg with fertilizers $N_{30}P_{60}K_{30}$, thereby forming optimal nitrogen nutrition regime for cultivated crop in the root zone. After harvesting soybean 70-80 kg / ha of assimilable nitrogen remain in soil, which equates to 2-3 centners of mineral nitrogen fertilizers or 30-40 tons of manure thereby reducing the environmental strain caused by the intensification of agriculture.

The improvement of crops rotations with increase of the share of environmentally beneficial legumes such as soybean provides science-based placement, improvement of soil fertility and productivity. Since there's no need for additional financial costs due to biological features of previous crop cultures, the structure of agro-ecosystem is optimized with decreasing amounts of weed.

Thus in order to restore elements and improve soil fertility in specific conditions of soil and climate under the agricultural intensification the necessary condition is to optimize the structure of the agro-ecosystem with increasing the portion of environmentally beneficial culture and applying optimal doses of mineral fertilizers.

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