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Strategy of production of leguminous cultures and soya in Steppe of Ukraine

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The purpose. To analyze state of production of leguminous cultures in steppe zone and prospects of development of branch on the basis of innovative means of production and technologies. **Methods.** Field, analytical, normative, comparative, mathematical-and-statistical production of data. **Results.** Directions of optimization of structure of sown area of bean cultures, their role in regulation of fertility of soils and increase of efficiency of agricultural animals are determined. Models of crop rotations with elements of biologization are brought at use of bean cultures. **Conclusions.** It is necessary to adapt leguminous cultures for system of regulation of nutritious regimen and increase of fertility of soils. Proposals are made for complex development of the branch. Bibliogr.: 10 titles.

Key words: *leguminous cultures, soya, crop rotations, fertilizers, humus, productivity, structure of sowings.*

Growing and production of leguminous crops and soybeans is an extremely important factor in the context of: 1) the implementation of the National Program "Grain of Ukraine", which provides for the annual production of 80 million tons of grain; 2) creation of effective mechanisms for increasing fertility of soils based on the accumulation of atmospheric nitrogen and accumulation of organic matter in order to enhance the humification processes; 3) providing of a qualitatively new forage base in order to improve the conversion of high-protein feed to livestock products [1-4].

It is obvious and clear that each individual task can not be solved beyond the complex solution of the problem.

Therefore, today, with the technological modernization of agriculture, the use of synthetic means of regulating of plant productivity and climate change, it is important to identify innovative guidelines in questions of land tenure, the structure of crop areas, the use of fertilizers, organic remains, the selection of varieties and hybrids, the legislative consolidation of scientifically grounded positions [5-8].

The ambiguity of the processes of production of high-combined crops is evidenced by statistical data that synchronously reflects, first of all, market relations and pushes the problem of ecology to the fore.

The analysis shows that occupying 43,7% of Ukraine's total sown area, in the Steppe zone of Ukraine, in 2015, 41,3% of leguminous crops and 14,8% of soybeans fell. The saturation of crop rotation with legumes (mainly peas) in 2015 was the largest in Zaporizhzhya and Odessa regions (1,7 and 1,9%), and soybeans in Kherson and Kirovograd regions (6,8 and 10,5%). In general, in the Steppe zone, leguminous crops in the structure of crops area occupied 0,9% in 2015 (as in the whole of Ukraine). At the same time, it is obvious that saturation of soybean crop rotation in the Steppe zone is significantly lower and is 2,7% against 8% in the whole of Ukraine.

The collected areas of leguminous crops in the Steppe zone of Ukraine decreased from 468 thousand hectares in 1990 to 102,8 thousand hectares in 2015, that is, in 4,6 times. At the same time during 2000-2015 they varied in the range from 85,6 (2000) to 166,1 (2012). Reductions of areas under traditional leguminous crops (especially peas) occurred not only due to the reduction of the livestock feed base, but above all under the influence of growing interest in other "currency" crops: sunflower, corn, oil radish and soybeans with a higher potential of profitability. In particular, if in 1990 the soybean area in Ukraine amounted to only 87,8 thousand hectares, then in 2015 – 2,14 million hectares, that is, it was 24 times its increase. Similar tendencies are characteristic for the Steppe zone of Ukraine. So, from 2000 to 2015 the harvesting area of soybeans increased 9 times (from 35,4 to 320,5 thousand hectares), reaching a maximum in 2012 – 342,1 thousand hectares.

The dynamics of leguminous productivity in the Steppe zone of Ukraine during 2000-2015 was characterized by instability and was dependent on weather and climatic conditions and the level of material and technical and technological support of the industry. It dropped twice to 7,4 c/ha (unfavorable in 2003 and 2007), and in some years it exceeded 20 c/ha, reaching its maximum in 2004 (24,9 c/ha). Soybean yields ranged from 10,2 c/ha in 2000 to 22,5-22,7 in 2013 and 2011. In general, during the study period, the yield of leguminous crops increased from 12,2 to 18,7 c/ha, and soybeans – from 10,2 to 22,0 c/ha.

Dynamic changes in the collected areas and yields of these crops have had a corresponding impact on the indicators of the formation of their gross yields. Thus, the maximum indicators of the production of leguminous crops during 2000-2015 were in 2006 (307,3 thousand tons), which is 3,5 times more than the minimum values – 86,5 thousand tons (2007). In 2015 192,5 thousand tons of legumes were harvested. The fluctuation of soybeans gross yields was almost 20 times: from 36,1 thousand tons in 2000 to 704,6 thousand tons in 2015.

In the Institute of grain crops it has been established that the biologization of agriculture, in particular, the inclusion of leguminous crops in the crop rotation and the use of organic remains, siderates and other organic components in the fertilizers system has a good effect on the preservation of soil fertility.

Leguminous crops is a favorable predecessor for winter wheat, one of the components of this phenomenon is that legumes enrich the upper part of the roots-conteining layer of the soil with well-digestible forms of nitrogen by only one-third less than that provided by the black fallow field, which is considered to be the best predecessor for wheat.

Of the 10 essential amino acids, the most complete one are lysine, leucine, arginine and phenylalanine. According to their content, more valuable nutrients are soybeans, peas and fodder beans. Wheat gives in to them in to all amino acids. Breeders have also created corn with high content of lysine, feeding of which increases the productivity of animals by 14-15%.

When feeding animals of 1 kg of wheat, you can get 950 g of milk, 24 g of live weight of pigs and 19 g of cattle gain; from 1 kg of peas respectively - 224 g of milk, 52 g of pig and 43 g of cattle gain; from 1 kg of soy - 268 g of milk, 61 g of pigs and 50 g of cattle gain. Thus, the most biologically complete (due to the amino acid composition) is the soybean, in the second place – peas, and wheat, as a feed, has the least nutritious value.

Today, a high result can only be achieved through the balance between the technological link and the genetic potential of varieties and hybrids of legumes.

The research farm "Krasnogradske" has an effective breeding group, which has created several high-yielding varieties of lentils, gooseberries, ranks, beans, soybeans and peas. In the competitive tests, the showed varieties indicated productivity, which is 1,4-2,0 times higher than the yield in the production conditions.

The prospects for further growth of gross yields of leguminous crops are preserved due to the still not fully utilized potential of productivity – 3,5-4,6 t / ha.

Taking into consideration the state of the problem of the production of legumes, it can be noted that in this area still remains unused reserves of their productivity and not achieved yet a significant improvement of the role of the environmental regulator.

When placing soya in short-rotation crop rotations, the saturation of crop rotation with the crops of this culture had not very large impact on the level of its yield. So, at 25% saturation with soybean 4-field crop rotation in the background of the optimal fertilization option, soybean yield was 2,30 and 2,38 t/ha, the same yield was found also at 50% saturation with soybean another 4-field crop rotation (2,33- 2,38 t/ha). At the same time, at 50% saturation with soybean of 2-field crop rotation (soybean - maize), soybean yield decreased slightly (2,22 and 2,26 t/ha), a similar phenomenon was observed also at 33% saturation with soybean 3-field crop rotation, especially on the background of chisel cultivation. This is probably due to the fact that with increasing the set of crops in the crop rotation, the processes of restoration of soil fertility are more complete, the level of phytotoxicity decreases, and the negative interaction of cultivated crops is reduced in a greater degree (table 1).

Table 1. Soybeans productivity in short rotation crop rotations, depending on the method of basic soil cultivation and fertilizer system, t/ha (average for 2008-2015)

Basic soil cultivation	Grain yield, t/ha			Gathering, t/ha					
				feed units			digestible protein		
	1	2	3	1	2	3	1	2	3
Two-field crop rotation (soybeans - corn)									
Plow	1,89	2,22	2,05	3,73	4,41	4,06	0,60	0,71	0,65
Chisel	1,86	2,26	2,09	3,67	4,48	4,13	0,59	0,72	0,66
(Soybeans – barley – corn)									
Plow	1,98	2,33	2,19	3,91	4,65	4,36	0,63	0,74	0,70
Chisel	1,88	2,23	2,00	3,71	4,45	3,97	0,60	0,71	0,64
(Soybeans – corn - barley)									
Plow	1,92	2,30	2,11	3,79	4,56	4,18	0,61	0,73	0,67
Chisel	1,81	2,19	2,06	3,58	4,36	4,09	0,58	0,70	0,65
(Soybeans – corn – corn – barley)									
Plow	2,02	2,30	2,19	3,99	4,55	4,34	0,64	0,73	0,70
Chisel	1,98	2,38	2,21	3,90	4,72	4,37	0,63	0,76	0,70
(Soybeans – barley – soybean - corn)									
Plow	2,02	2,33	2,18	3,97	4,63	4,31	0,64	0,74	0,69
Chisel	2,00	2,38	2,19	3,95	4,72	4,33	0,64	0,76	0,70

1 - control without fertilizers; 2 - fertilization in accordance with the agro-chemical diagnostics of the soil; 3 - recommended doses

During the research period (2008-2015), the dependence of the soybean yield on mineral fertilizers was observed. The best conditions for the growth, development and formation of crops with soybean crops were provided at its planting in areas with application of fertilizers in accordance with the requirements of the standard method of consumption of nutrients for the formation of a unit of yield, taking into account the agrochemical characteristics of the soil (var. 2). Compared with the control variant without fertilizers, the grain obtained here was 14-21% more. When making recommended doses of mineral fertilizers (var. 3) soybeans is collected by 5-11% less than in the variant taking into account the results of agrochemical analysis. This indicates the need for agrochemical studies to adjust the recommended fertilizer norms when growing plants in a specific field.

The explored tillage systems did not have a sufficiently pronounced difference in the effect on the soybeans productivity, only a slight tendency towards a somewhat higher level of crop was noted against the background of the plowgh soil cultivation system (within the experimental error).

Similar dependencies were found also in the analysis of indicators of the collection of feed units and digestible protein.

The experiments carried out at the Erastivka research station show that in choosing the optimal fertilizer system and the main cultivation of soil, effective cultivation of soya in short-rotation crop rotations is possible even with 50% saturation of crop rotation with its crops.

Stationary experiments at the Kirovograd research station have shown that from the standpoint of productivity of crop rotation in the structure of the crop areas for soya there are some restrictions caused by the peculiarity of the decomposition of its remains.

Cultivation of crops in crop-fallow-tilled rotation crop rotation with saturation by soybean up to 20% by organo-mineral fertilizer system with the use of microbial preparations contributed to a greater increase in productivity. Under these conditions, the increase in feed, cereal units and digestible protein was 0,93 t/ha (19,6%), 1,14 t/ha (21,6%) and 0,19 t/ha (29,7%) respectively (table 2).

Table 2. Productivity of crop rotation depending on the fertilizer system, microbial preparations and soybean saturation, t / ha of crop area (2011-2015).

Crop rotation	Fertilizer system	Microbial preparations	Cereal units	Fodder Units	Permeated protein
Grain-tilled (20% soya)	No fertilizer	-	4,52	5,08	0,59
		+	4,74	5,28	0,62
	Mineral	-	4,85	5,42	0,64
		+	5,04	5,60	0,67
	Organo-mineral	-	5,38	6,13	0,77
		+	5,67	6,42	0,81
Grain-tilled (40% soya)	No fertilizer	-	4,08	4,90	0,50
		+	4,40	5,26	0,54
	Mineral	-	4,48	5,37	0,55
		+	4,69	5,61	0,58
	Organo-mineral	-	4,53	5,42	0,56
		+	4,74	5,66	0,58
Grain-tilled (60% soya)	No fertilizer	-	4,40	4,99	0,59
		+	4,60	5,18	0,62
	Mineral	-	4,59	5,20	0,61
		+	4,79	5,40	0,64
	Organo-mineral	-	4,68	5,30	0,63
		+	5,03	5,66	0,68
Sustainable Growing Soybeans	No fertilizer	-	3,76	3,24	0,64
		+	3,84	3,31	0,65
	Mineral	-	4,03	3,47	0,68
		+	4,03	3,47	0,68
	Organo-mineral	-	4,16	3,58	0,70
		+	4,28	3,69	0,72

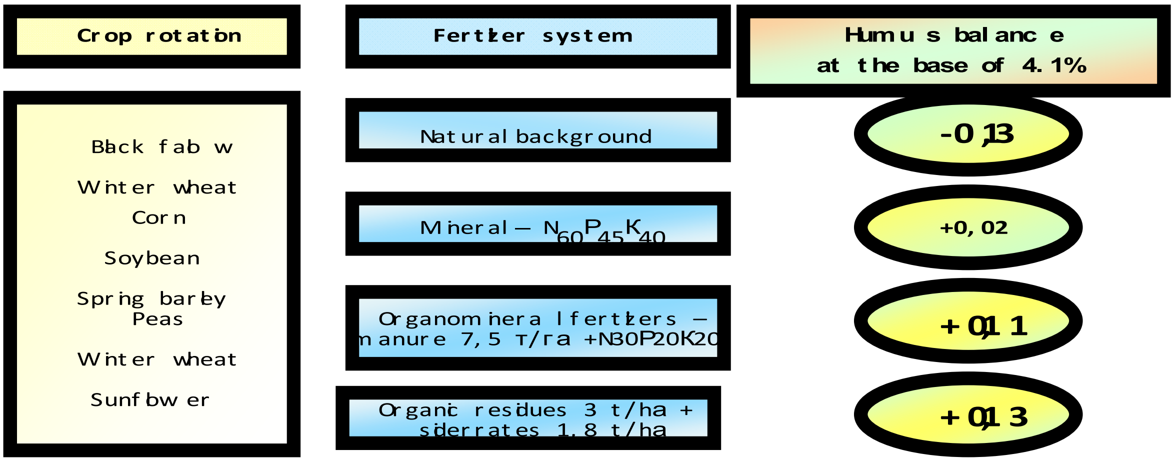
A greater increase in feed and grain units from the use of microbial preparations was also obtained by the organo-mineral fertilizer system, which amounted to 0,29 t/ha (5,3%) and 0,29 t/ha (4,7%). Greater increase in the yield of digestible protein in grain-fallow-crop rotation, using microbial preparations was in variants with an organo-mineral fertilizer system and with no fertilizers was 0,04 t/ha.

In grain-tilled crop rotations with soybean saturation 40% and 60% use alone of fertilizers and in combination with by-products ensured an increase in yields of cereals, feed units and digestible protein at levels of 4,3-11,0% and 4,4-11,5% compared to non-fertilizer variants. With the combined application of microbial preparations in mineral and organo-mineral fertilizer systems in crop rotation with soybean saturation 40 % indicators of productivity increased by 6,4-7,8 %, and in crop rotation saturated soy up to 60 % – by 4,1-15,3 %.

When cultivating soybeans in unchanged crops, the productivity growth of the crop rotation area on the mineral fertilizer system was 4,8-7,2%, for the organo-mineral system 10,6-11,3%.

The positive balance of humus in the soil can be achieved without the use of mineral fertilizers. The key elements of such a regenerative system are making of plant remains, nutrient and fallow siderates in the soil and the introduction of two asymiliated legumes peas and soy into the crop rotation. At the same time use as organic fertilizer straw and large-staple remains 3 t/ha in combination with 1,8 t/ha oil radish in the form of green mass provides equivalent of manure 12 t/ha and an annual increase in the content of humus by 0,015% (table 3).

Biological factors in soil fertility regulation (according to the data from Erastivska research station of SI Institute of Grain Crops of NAAS, Ukraine), 2008-2015



Thus, we can convincingly say that methods have been found to ensure a sustainable tendency to increase the soil fertility on the basis of the rational use of organic remains produced during the process of photosynthesis.

The newest history of agriculture is characterized by the fact that in the process of land use it is necessary to achieve the simultaneous growth of both crop and soil fertility.

Comparison of fertilizer efficiency in crop rotation in terms of impact on crop productivity has also shown a high ability to provide high productivity. In this case, the model of biological agriculture based on the use of organic material in the form of plant remains and siderates turned out to be most promising in the conditions of deficiency of traditional organic fertilizers. As can be seen from table 4, there is a multivariate opportunity to solve the problem of efficient land use. Option one: introduction of a mineral fertilizers system and obtaining maximum yields. However, high enough doses of mineral fertilizers of NPK - 145 kg/ha a.s., the growth of production costs and practically full absence of positive dynamics of fertility of chernozem can not provide the status of the basic concept of development of agriculture in the steppe zone.

Table 4. Systems of regulation of nutrition regime and productivity of crop rotation crops, t/ha, 2013-2015

Black fallow	Winter vheat	Corn	Soybeans	Spring barley	Peas	Winter wheat	Sunflower
On the background of the natural fertility potential							
-	4,63	4,16	1,96	2,46	2,86	3,97	2,52
Mineral fertilizers – $N_{60}P_{45}K_{40}$							
-	5,71	5,51	2,40	3,39	3,28	5,02	3,62
Organo-mineral fertilizers - manure 7,5 т/ra + $N_{30}P_{20}K_{20}$							
-	5,49	5,30	2,31	3,11	3,25	4,55	3,44
Bulletins of agricultural crops 3 t / ha + siderates 1.8 t / ha							
-	5,64	5,38	2,36	3,30	3,25	4,94	3,54

Along with this, the concept of agricultural development based on biologization and the inclusion of organic remains in the active cycle of agricultural crops is more beneficial for economic consequences and a rather high productivity.

If the mineral fertilizer system $N_{60}P_{45}K_{40}$ exceeded the biological one based on organic mass by indexes of corn productivity on 0,13 t/ha, then the complex ecological and economic advantage of the biological system was formed due to the positive balance of humus with a dynamics of + 0,13%.

The main directions of the scientific and methodical strategy of production of high-protein crops and the implementation of the concept of ecological balance in agro-systems should be deployed around a complex of such issues as:

- Creation of a legislative framework for the effective functioning of agro-systems, which will ensure the growth of their productivity and environmental integrity;
- Formation of the latest ecological culture, mechanisms of control and renewal of resources in the field of agricultural activity;
- To development of methods of regenerative agriculture needs to bring the proportion of leguminous crops to soybean and perennial grasses in the structure of crops to 5-15%;
- Extension of the basic collection of the gene pool of legumes and the creation of varieties and hybrids with a grain yield potential of 45-65 centners per hectare;
- Development of ecologically safe technologies for growing leguminous crops on the basis of effective moisture utilization and energy saving;
- Adaptation of leguminous crops to the system of regulation of nutritional regime and increase of fertility of soils;
- Development of technologies for rational use of water on irrigated lands;
- Implementation of a unified model of agrobiological and ecological and economic evaluation of the effective production of high protein crops.

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