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THE ROLE OF PULSE CROPS (ALFALFA, SAINFOIN) IN SOIL FERTILITY ENHANCEMENT

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In 91 years after the development of mountain and steppe black soil, percentage of humus of these soils decreased by 21-27%. Annual losses of humus 0.30-2.0 t/ha. Much less than the annual losses of humus in soils

with relatively low fertility: the black earth of South – 0,30-0,80 t/ha, sod-carbonate – 0,50-1,5 t/ha, brown-carbonate – 0,40-1,60 t/ha, meadow-brown-washed – 1,10 t/ha, taupe – 1,30 t/ha and meadow-alluvial-carbonate – 0,80-1,80 MT/ha. For the period through anthropogenic load reserves of humus mining and ordinary Chernozem decreased by 22-25%, and the nutritional elements nitrogen, phosphorus and potassium, respectively, at 32-16, and 24%. Stocks of humus of chernozems of the South, grey-brown, meadow brown and alluvial soils decreased respectively 22-20-17 and 24%. It should be noted the fact that through the implementation of farming and the large number of returned plant residues on the space occupied vegetable crops the contents and stocks of humus more than on land mastered under crops. Sowing of perennial grasses and introduction as fertilizer straw and green manure legumes increases soil fertility and provides an increase in reserves of humus 2-3 shades within three years. The sowing of winter crops and legume mixtures (clover-bluegrass-bentgrass) on the slopes of 150% is the best way to restore and improve the erosion properties of soils. The use of alfalfa with bollaram contributes to the demineralization of saline soils, an increase in grain yield from 1.5 to 3.0 t/ha.

2 years after use of alfalfa salinity reclamation of soils is not marked. The efficiency of recovery of soils polluted by pesticides is evident in the third year of the experiment, after planting corn.

Keywords*: soil fertility, degradation, balance of humus, pulse crops.*
Tab. 3. Lit. 10.

Introduction. Georgia is a country with limited land recourses. A significant part of the arable lands are degraded, which represents 35% of total agricultural plots. The process of soil degradation in Georgia is determined by: the climatic and landscape peculiarities, activity of geo-dynamic processes, uncontrolled cutting of the forest trees and inappropriate agricultural activities, such as, inefficient application of fertilizers, uncontrolled grazing, plowing and seeding on slopes, open mining of minerals, and etc [1].

Research methods. In order to identify how the pulse crops (alfalfa and sainfoin) effect on soil fertility it was important to study East Georgia black soils with a strong focus on lowlands and highlands. To specify upper and lower bio-masses, N. Bazilevich and others [2] methodology was applied. Also, soil humus balance was determined based on methodology of P. Kordunianu [3].

Research results. The agricultural lands of Georgia can be characterized by: high natural fertility (38%), medium fertility (21%), and low fertility (41%). The high fertility usually decreases in the result of high yield of agricultural crops (70-80%). For example,

during the past 80 years, the percentage of humus in highly fertile soils (both in the lowlands and highlands) - has sharply decreased by 21-27%, and instead of former 6,50-6,22%, today we have 5,15-4,55%. The loss of humus after harvest in lowland ordinary chernozem fertile soils is 2,0 ton per hectare. In middle fertile lands, annual loses are respectively low; but for the soils, such as: southern chernozems carbonate, calcareous soil, meadow carbonate, brown carbonate soil and grey calcareous soil it equals to: 0,30-80; 0,50-1,5, 0,40-1,60 1,10 and 1,30 ton per hectare.

For the lands with respectively lower fertility, such as, the meadow-alluvial soil and brown carbonate soil the annual loss of humus is 0,80-1,80 tons per hectare. The humus store in the lowland and highland chernozem soils has decreased by 22-25%, and the amount of the basic elements, such as nitrogen, phosphorus and cilium – respectively by 32-16 and 24%. Southern chernozem, grey-brown soils, meadow grey – brown and alluvial soils humus store has decreased by 22-20-17 and 24%. Also, it should be noted that the plots with vegetable crops have higher percentage of humus supplies because it gets better agro-technical services and better return of organic minerals if compared with the lands occupied by crop cultures [4].

A certain period of time is necessary for cereal plant deposits to decompose in the soil, (about 2-3 years), consequently, the amount of of humus is not present in large amount and equals to 3,80-6,10 c per ha. So, we think that in order to re-construct, retain and get high yield, it is necessary to inseminate perennial legume crops which have positive balance, and add organic fertilizers, such as, straw and legumes siderate together [5].

It is well known that, legume crops play an important role in the process of raising fertility of soil. The legume crops are of different types – annuals and perennials. It is typical for them to have callus bacteria on the roots which fix nitrogen from atmosphere. The amounts of nitrogen fixed by different crops vary a lot. For example, from overall amount of nitrogen which perennial crops, such as sainfoin and alfalfa get from atmosphere, the 65-80% is fixed nitrogen. That means that from this point of view they differ from other crops as they less deplete the soils not only from nitrogen, but also by humus, which is the main indicator of soil fertility. Besides, legume crops develop very strong root system and return to soil organic remains (59-61%).

The overall amount consumed by alfalfa during one year equals to 2189, 23 kg per hectare, from which the soil looses 42% of used nitrogen in the result of collecting hay, and from roots the soil gets 58% of nitrogen. Nitrogen is the chief element which is responsible for humus formation, and consequently it helps to raise fertility. It is evident that in a field sowed with perennial grasses, the balance of humus in soil is positive in compare with other annual and perennial agricultural crops. The humus is concentrated in the top soil. The alfalfa return coefficient is 0,58 and is 2,3 times higher in compare with wheat.

Perennial crops sainfoin and alfalfa are one of the best predecessors of agricultural crops. They enrich soil with organic substances. The plant remains

(straw) of those plants are rich with potassium and calcium which helps concentration of high quality humus and increase of first priority nutritious elements in soil. The return of minerals as remains from legume crops, and particularly from alfalfa annually equals to: nitrogen – 1263,49 kg/ha, phosphorus 107,85 kg/ha, and potassium 924,02. The indicated amount of nutritious elements can meet the demands of the following crops for nutrients [6].

Below, a table 1 is provided which presents positive influence of perennial leguminous grasses on soil fertility. The presented materials show that under wheat, ordinary chernozem soil contains humus in upper layer 5,15%, and in the plots occupied by sainfoin, humus is higher by 0,45% and reaches 5,60%, besides, distribution of humus according to bedrocks according of horizonts is more even [7].

Table 1

Some chemical measures of ordinary chernozem

Arable land, Location	Depth	Humus, %	Nitrogen, %	$CaCO_3$, %	Absorbed bases (mg) on 100 g soil		
					Ca	Mg	Total
Wheat, Zemo Qedi	0-10	5,15	0,210	3,2	38,8	5,1	43,9
	23-33	4,22	0,180	5,0	36,4	5,2	41,6
	37-47	2,05	0,120	8,1	30,3	5,2	35,5
	50-60	0,96	0,070	16,7	26,5	4,5	31,0
	65-75	0,71	0,040	21,0	26,3	5,0	31,3
	93-103	0,51	–	22,3	22,4	7,1	29,5
	150-160	–	–	21,6	20,8	7,3	28,1
Sainfoin, Zemo Qedi	0-10	5, 60	0,220	3,1	38,4	5,4	43,8
	22-32	4,47	0,190	5,5	37,8	5,4	43,2
	35-45	2,65	0,120	7,6	28,8	4,1	32,9
	53-63	1,09	0,070	17,8	25,2	4,3	29,5
	68-78	0,80	0,050	20,8	22,6	6,6	29,2
	100-110	0,55	–	22,9	21,6	7,5	29,1
	135-145	–	–	20,4	20,7	7,3	28,0

Source: based on own research

Based on investigations carried out by M. Sabashvili Research Institute of Soil Science, Agro chemistry and Melioration which deals with humus balance in ordinary chernozem soil, it can be concluded that the plot occupied by Spring wheat and barley, potato and sainfoin, the positive balance of humus +15,45 c/ha (table 2) is identified on the plot occupied by sainfoin. This is preconditioned by existence of plant remains rich with nitrogen and other nutritious elements [8].

Many laboratory and outdoor tests testify that the hills which have more than 15^0 slope, it is advisable to saw perennial grassy crops and annual grain and leguminous crops which will help to the rehabilitation and improvement processes of fertility of erosive soils. The best results are obtained from combination of clover-meadow grass-bentgrass [9]. The implementation of the given recommendations will

enable the farmers living in the highland regions to use 25° slopes for sawing crops even under annual crops.

Based on investigations carried out by M. Sabashvili Research Institute of Soil Science, Agro chemistry and Melioration, the Department of Melioration in 2006-2011, it has been identified that perennial leguminous grasses are the best bio-meliorants. The measures of agro-biological melioration fundamentally change the quality of soil under the process. Deep plow reduces the solidity of solonetz and its volume weight.

In the result of tillage soil pores swell, aeration, water-passage and the amount of productive moist increases. In irrigated soils of dry zones, the best option is to sow the yellow (M. Falcata L.) and light blue alfalfa (M. Col rulea Jess).

Table 2

Mountain ordinary chernozem humus balance centner /ha

Balance stages	Winter Weat	Winter Barley	Potato	Sainfoin
Humus mineralization, Nitrogen biological output from soil centner/ha	1,86	1,25	2,41	5,02
– Symbiotic nitrogen centner/ha				3,51
– Non symbiotic nitrogen centner/ha	1,86	1,25	2,41	1,51
Humus loses from soil (K=12) centner/ha	22,32	15,00	28,92	18,12
Number of plant residuals returned to soil centner/ha	41,59	31,43	32,39	137,85
Number of humus derived from plant residuals K=0,20-0,08-0,022 centner/ha	8,32	6,29	2,59	30,33
Humus compensation with mineral fertilizers centner/ha	11,04	5,58	19,50	3,24
General Humus compensation centner/ha	19,36	11,87	22,09	33,57
Humus balance centner/ha	-2,96	-3,13	-6,83	+15,45
Scope of balance centner/ha	41,68	26,87	51,01	51,69
Balance intensity, %	86,74	79,13	76,38	185,26

Source: based on own research

Alfalfa can absorb a large quantity of water which decreases the land water level. Also, the concentration of salts in the upper layer of soil decreases. Different from wheat and barley, the roots of which are located in the plow level and are developed horizontally, alfalfa develops a very strong root system which can thrust through solonetz level and allocate deeply in soil profile. The roots of alfalfa till the soil decompose minerals and sharply change the migration character of migration of mineral feeding elements. For some years, there has been no attempt to restore salinization on irrigated lands. Also, it should be noted that only during one year in the result of decay of organic mass of alfalfa, the soil gets back 37 kg/ha aluminum, which is easily absorbed by agricultural grain crops. This significantly increases its resistance to drought. High concentration of high amount of calcium – 190 kg/ha

supports appearance of humus. The siderites of leguminous crops with high percentage of nitrogen introduced in the soil determines an increase of newly produced humus minimum 2-3 t/ha during three years. So, consequently the amount of wheat yield increases up to 1,5 –to 3,0 tons.

In 2007-2010, at *L. Kanchaveli* Research Institute of Plant Protection, scientific studies were conducted on: "The rehabilitation of the soils contaminated by the pesticides." The testing site was village of *Arboshiki*, in the Region of *Dedoplistskaro*, on the ordinary chernozem on the territory of the warehouse where pesticides of different chemicals were kept. Among them sustainable organic clorin, heterocyclic and etc. In order to eliminate soil contamination, corn was used, which is resistant to simtriazins because of high consist of 2.4-diox-7, metox-1.4-benzoxasinon-4. Besides of this root of corn highlights N-oxibenzoxazinon and help to hydrolize of simtriazins` lees.

In order to rehabilitate soil, some plants which have phyto-remedial quality, such as alfalfa and sainfoin. Before the experiment was started, agro-technical treatment of the soil started, such as, plow, cultivation, irrigation and introducing some chemicals, such as peat and ceolit.

For the last twenty years, in the result of soil contamination, decrease of micro-biological activity and because agro-technical measures were not taken, amount of humus in contaminated soil has been decreased by 17%. IN soil, The level of existence of this element is rather small – 0,19% and 5,5 mg 100 gr. in soil.

Chernozem soil is very poor with common and moving forms of phosphorous (0,13 and 1,98 mg in 100 gr, soil), though, it is accommodated with exchange potassium 35,18 mg – 100 gr. soil, which, like nitrogen and phosphorus decreases by depth. This kind of soil is carbonated. The amount of $CaCO_3$ in profile varies from 3,2 to 17,1%. The (content of absorbed bases) amount of merged basis is very high and equals to 31-42%. It also contains calcium 86%.

The soil from the top is a week alkaline – 7,8 and in depth it becomes more alkaline – 8,6. We think it is determined the existence of Heterocyclic compounds in soil.

The results of microbiological researches indicate that to decrease of micro-organism activity in the investigated soil, also to slowing down the processes of mineralization of organic substances and of humus-creation. The number of all physiological groups of microorganisms is significantly decreased. The most vulnerable to contamination turned out to be the cellulose-decomposers. Calculation of their number in the layer of soil was impossible. Also the number of saprophyts in 0-40 cm soil layer is 920-886 thousand 1 gr. in the absolutely dry soil.

In dry soil, the amount of spores in compare with control version, is reduced by 39% and constitutes 470-298 thousands. Also 96% decrease is depicted in anaerobic Clostridium Pasterianum – 32,5-27,3 and actinomicetes 1187-710 thousand grams and it is reduced. Comparatively stable were nitric -bacterium 65-60% and nitrifications 0,110-0,108 th. 1 gr. in the absolutely dry soil. The amount of

nitrifications in compare with control group was only reduced by 15-13%. From bacteria the adults are less depressed on mineral area, and consequently their amount according to layers reaches 2270-1190 thousand in 1 gr. absolutely dry soil.

After the rehabilitation works have been carried out, on the third year, because of soil detocsication, micro-biological activity sharply rises, and its amount is close to those in a control soil. The amount of humus also increases by 0,5% and reaches 4,88%. The reaction of soil is pH=7,4 is already the same as it is in control one. The amount of hydrolysis nitrogen is a little bit more than in the control soil – 7,22-5,20 mg in 100 g soil. The amount of phosphorus which should be absorbed is equals to control soil data and ranges between 2,37-1,54 mg. in 100 g soil. The amount of potassium ranges according to layers between 36,80-33,68 mg. in 100 g soil.
What is lower compare with contro – 6,41-1,30% (table 3). This may be conditioned by deposit of low dose of potassium in soil, and also because corn and alfalfa consume big amount of potassium. The results indicate, that the effectiveness of rehabilitation works demonstrates its results in the third year. The structure of testing cultures (crops) on rehabilitation plots is the same as on the control plots, but the yield crop harvest on rehabilitated plots is higher in compare with the control one [10].

Table 3

The amount of humus and feeding element absorbing forms in ordinary chernozem soil contaminated with pesticides, after two-and-a-half year of rehabilitation works

Depth of taking sample (sm)	Humus %	pH in squeezed water	Food elements absorbing forms (mg) in 100g soil		
			N	P	KKN
Polluted Soil					
0-20	4,88	7,4	7,22	2,37	36,80
20-40	2,61	7,6	5,20	1,54	33,68
Control					
0-20	5,15	7,4	6,80	2,39	43,21
0-40	4,75	7,6	4,50	1,50	35,03

Source: based on own research

Conclusion. Based on many-year studies we can come to the following conclusions:

The decrease of fertility of any soil starts after cultivation of virgin (virgin) land. The percentage of humus in lowlands and highlands chernozem soil after 80 years of agricultural use is decreased by 21-27% in compare with un-used lands.
The annual loss of humus in the result of harvest is 2,0 tons per hectare. During this period, because of anthropogenic influence, the humus deposits in above mentioned soils have been decreased by 22-25%, and subsequently the major deposits of feeding elements, such as nitrogen, phosphorus, and potassium also decreased by 32-16, and 24%. Sowing of perennial legume crops and the combined use of alfalfa and legume siderites as fertilizers, considerable increase soil fertility, and supports the increase of

humus minimum up to 2-3 tons per hectare in three consequent years. On the slopes with 15^0 and more decline, sowing of grain-legume grassy-clover-meadow grass-bentgrass combinations is in order to the best practice to restore and enhance soil fertility, increase harvest and to protect the slopes from erosion. The use of alfalfa as a biomeliorant helps deselination process of solonetz soils, and consequently, the increase of wheat crop up to 1,5 – to 3,0 tons. Two years after the use of alfalfa, the restoration of salination on the lands which are meliorated, is not depicted.

The effectiveness of rehabilitation works carried out on soils damaged by the pesticides can be identified only on the third year of the experiment. On this stage the structure of testing crops on testing plots is the same as on the control ones; but the crop harvest on the rehabilitated soils is higher in compare with the control one.
In order to raise the fertility of degraded soils and to get ecologically pure product, it is necessary to restore the seed rotation plot rotation for the crops, and to increase the area of perennial legume plants up to 25%.

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АНОТАЦІЯ
РОЛЬ БОБОВИХ КУЛЬТУР (ЕСПАРЦЕТ, ЛЮЦЕРНА) В ПІДВИЩЕННІ РОДЮЧОСТІ ҐРУНТУ

Через 91 рік після освоєння гірських і степових чорноземів, відсотковий вміст гумусу цих ґрунтів зменшився на 21-27%. Щорічні втрати гумусу складають 0,30-2,0 т/га. Набагато менше щорічні втрати гумусу на ґрунтах
із порівняно низькою родючістю: чорноземах південних – 0,30-0,80 т/га, дерново-карбонатних – 0,50-1,5 т/га, коричнево-карбонатних – 0,40-1,60 т/га, лучно-коричневих-змитих – 1,10 т/га, сіро-коричневих – 1,30 т/га і лучно-алювіальних-карбонатних – 0,80-1,80 т/га. За зазначений період через антропогенне навантаження запаси гумусу гірських і звичайних чорноземів зменшилися на 22-25%, а поживних елементів азоту, фосфору і калію відповідно на 32-16 і 24%. Запаси гумусу чорноземів південних, сіро-коричневих, лучно-коричневих і алювіальних ґрунтів зменшилися відповідно на 22-20-17 і 24%. Необхідно відзначити той факт, що через впровадження заходів агротехніки і великої кількості повернених рослинних залишків на площах зайнятих овочевими культурами вміст і запаси гумусу більші, ніж на угіддях, освоєних під зерновими культурами. Сівба багаторічних бобових трав і внесення в якості добрив соломи і сидератів бобових культур збільшує родючість ґрунту та забезпечує збільшення запасів гумусу на 2-3 тони впродовж трьох років. Посів озимих і бобових травосумішей (конюшина-тонконіг-мітлиця) на схилах з ухилом 150% є найкращим засобом відновлення і поліпшення властивостей ерозійних ґрунтів. Використання люцерни біомеліорантом сприяє знесолення солонцевих ґрунтів, збільшення врожайності зернових від 1,5 до 3,0 т/га.

Через 2 роки після використання люцерни засолення меліоративних ґрунтів не відмічається. Ефективність відновлення ґрунтів забруднених пестицидами проявляється на третій рік експерименту після сівби кукурудзи.

Ключові слова: *еспарцет, люцерна, гумус, чорнозем, бобові культури.*

Табл. 3. Літ. 10.

АННОТАЦИЯ
РОЛЬ БОБОВЫХ КУЛЬТУР (ЭСПАРЦЕТ, ЛЮЦЕРНА) В ПОВЫШЕНИИ ПЛОДОРДИЯ ПОЧВ

Спустя 91 лет после освоения горных и степных чернозёмов, процентное содержание гумуса этих почв уменьшилось на 21-27%. Ежегодные потери гумуса составляют 0,30-2,0 т/га. Гораздо меньше ежегодные потери гумуса на почвах с сравнительно низким плодородием: чернозёмах южных 0,30- 0,80 т/га, дерново-карбонатных 0,50-1,5 т/га, коричнево-карбонатных 0,40-1,60 т/га, лугово-коричневых-слитых 1,10 т/га, серо-коричневых 1,30 т/га и лугово-аллювиальных-карбонатных 0,80-1,80 т/га. За отмеченный период из-за антропогенной нагрузки запасы гумуса горных и обыкновенных чернозёмов уменьшились на 22-25%, а питательных элементов азота, фосфора и калия соответственно на 32-16 и 24%. Запасы гумуса чернозёмов южных, серокоричневых, лугово-коричневых и аллювиальных почв уменьшились соответственно на 22-20-17 и 24%.

Надо отметить тот факт, что из-за лучшей агротехники и большого количества возвращаемых в почву растительных остатков на площадях занятых овощными культурами содержание и запасы гумуса больше, чем на угодьях, освоенных под зерновые культуры.

Посев многолетних бобовых трав и внесение в качестве удобрения соломы и сидератов бобовых культур увеличивает плодородие почвы и обеспечивает увеличение запасов гумуса на 2-3 тони в течение трёх лет. Посев озимых и бобовых травосмесей (клевер-мятлик-полевица) на склонах с уклоном 15° является наилучшим средством восстановления и улучшения свойств эрозионных почв. Использование люцерны биомелиорантом способствует обессоливанию солонцовых почв, увеличению урожайности зерновых от 1,5 до 3,0 т/га. Спустя 2 года после использования люцерны реставрация засоления мелиоративных почв не отмечается. Эффективность реабилитации почв загрязнённых пестицидами проявляется на третий год эксперимента после посева кукурузы.

Ключевые слова: *эспарцет, люцерна, гцмус, чернозем, бобовые культуры*

Табл. 3. Лит. 10.

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