Changes in the dynamics of humus of the soil content in the continuous sowing of cotton

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Abstract. This article is one of the only long-term scientific experiments in Central Asia, which has been conducted for 96 years since 1926 at the Scientific Research Institute of Cotton Breeding, Seed Production and Agrotechnology in Kibray district of Tashkent region. Option 1 monoculture, 30 t / ha fertilizer per hectare + 30 kg / ha phosphorus per year, Option 2 monoculture, N P K - 250:175: 125 kg / ha per year and Option 3 monoculture, absolute fertilizer, control options humus content 96 analytical scientific data on changes during the year. In the article, the highest decrease in humus content was observed in the control variant where was not used fertilizers, the amount of humus after 20 years was 21.4% or 11.4 t / ha compared to the initial amount, after 40 years it was 30.9% or 16.46 t / ha, after 60 years it was 35.7% or 19.05 t / ha, after 80 years it was 49.3% or 26.29 t / ha, and 54.3% or 29.17 t / ha after 96 years, this indicator is 12.2% -6,487 t / ha. In the experiment, the highest rate of humus reduction for 96 years was 54.3% in the control variant, 30 t / ha of manure + 25 kg / ha per year in P2O, 47.5% in variant 1, N P K - 250:175:125 kg / year. The norm was found to decrease by 36.9% in variant 2, where the norm was applied.
Keywords: Soil fertility, organic compound, organic residue, carbon, humus, nitrogen, microorganisms, nutrients, permanent cotton, crop rotation.

1 Introduction

The modern concept of the farming system is a variety of forms of farming, which includes a complex of agro-technical, reclamation measures and appropriate measures for the intensive use of land, restoring and increasing soil fertility [1-4].

One of the only issues in increasing soil fertility is the problem of humus formation in this soil [5]. Humus is the most important element of the biosphere and serves to synthesize and increase the amount of biomass in the soil [6]. The increase in the amount of humus in the soil, of course, depends on the amount of organic residue remaining in the soil [7, 8].

There are about 300 large and small experiments in the world that have been conducted for many years. One of such long-term experiments is the experiment conducted at the Scientific Research Institute of Cotton Breeding, Seed Production and Agrotechnology since 1926 for 96 years on the topic "Soil fertility in continuous cotton and crop rotation." The experiment was carried out in 1926 by A. S. Founded by Makarov. In the first year of the

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experiment, variants 1, 2, 3, 4 were formed, in 1935, variant 5, and in 1985, variants 6, 7, 8 were created [9].

Now we will briefly introduce some of the experiments that have been conducted in the world for many years and the data obtained from them, which is similar to this experience.

The Rotamsted Scientific Experimental Station in England was founded in 1843 has 17 years of experience in studying the fertility of the soil. The founder of this experiment is John Looz. The main purpose of this experiment is to study the need to feed plants with nitrogen fertilizers and the degree of assimilation of nitrogen fertilizers by plants. In the experiment, wheat and turnip monoculture were introduced in 1843 on heavy sandy soils with a mixture of lime in the initial variants, and later in 1852 a barley monoculture was introduced. In this experiment, without fertilizers (control), 35 t / ha of manure per year, against the background of fertilizers such as P K Mg Na, the norms of ammonium sulfate from nitrogen fertilizer were 47, 94 and 141 kg / ha, K2SO4 and Mg(SO4)2; Norms of fertilizers and terms of their application in variants such as N K Na Mg + rapeseed were studied. The option area ranged from 800 m2 to 2000 m2. The experiment was performed without repetition. In addition, a 4:2:4:2:4:4:2 rotation system was introduced from 1876.

From this experiment, it was found that long-term use of organic and mineral fertilizers significantly affected the amount of humus and nitrogen in the soil. After 100 years, the amount of humus and nitrogen in the variant where 35 t / ha of manure was applied annually was twice as high as in the non-fertilized control variant. In the control variant, the amount of humus did not change for almost 80 years, and in the variant with full application of mineral fertilizers, the amount of humus and nitrogen was higher than in the control variant. However, even when nitrogen fertilizers are applied to the soil every year, their amount is observed to decrease after 50 years. Although the decrease in nitrogen content in the experimental crop rotation options was not strongly observed in the first 30 years of the experiment compared to the control option, however, it was found that the decrease was strong in the next 20 years. Therefore, it was found that the same amount of nitrogen was retained after 50 years, both in the monocultural variant of the experiment and in the crop rotation [10].

From this many years of experience, it can be concluded that when plants were grown without fertilizer in a field for a long time, the amount of humus and nitrogen in the soil, as well as the yield, decreased. In the case of full application of mineral fertilizers, the amount of humus and nitrogen in the soil is slightly controlled and the yield is higher.

Another similar experience is the Greenon field experience, not far from Paris. The experiment was founded in 1875 by the French chemist Pierre Degeren. The experiment consisted of 68 variants, with three fertilizer-free (control) variants established in 1875, 1902, and 1931, in addition to NPK; NP; NK; PK; options that apply 10 t / ha of manure per year. Beginning in 1929, crop rotation systems were introduced. The soil is sandy.

From this experiment, it was found that for more than 70 years, the amount of humus and nitrogen in the soil decreased in all variants except the fertilized variant, in the more fertilized control variant. In the case of fertilizer, the amount of these nutrients was relatively low.

It can be concluded that even the annual application of mineral fertilizers in the cultivation of plants in a field for many years in the sandy and loamy soils of France does not maintain the required amount of humus and nitrogen in the soil.

The experiment began in Pennsylvania, United States of America in 1869, where the experiment consisted of 144 options. In experiment, corn, oats, wheat and clover are grown in fertilizer-free variants as well as in 4-field crop rotation systems. According to the data obtained after many years, the amount of nitrogen in the non-fertilized variant was 68.2%, which is 40.0% of the nitrogen in the variants, 42.0% of the variants in the P K given, N P K norms were given in full and were 11.9% higher than the nitrogen content in the alternately planted variants. Similar data were obtained on the amount of humus in the soil.

According to long-term experience in Missouri, the amount of nitrogen in the soil was lost from 27.3% to 56.3% in the variants where different crops were grown in the same field for 50 years, and in the alternate cropping options were from 25% to 40%.

In an Ohio State experiment, nitrogen content in the soil decreased by 39% after 25 years when corn and potatoes were planted in one field, and by 30% when soybeans were planted. Such data have also been proven in experiments conducted in Canada. In these experiments, the amount of humus and nitrogen in the soil decreased less in the first years of the experiment and more in the following years.

In an experiment founded in 1878 by Professor Julius Kyun in the German province of Gall, there were six variants, variant 1 without fertilizer, variant 2 N 40 kg / ha; 3rd variant PO 56 kg / ha, KO 90 kg / ha; 4th variant N 40 kg / ha, PO 56 kg / ha, KO 90 kg / ha; 5th variant manure 12 t / ha; in variant 6, fertilizer was 6 t / ha from 1893 to 1925, 8 t/ha from 1925 to 1953, the fertilization giving was stopped from 1953. The experiment was carried out in fields where rye was planted continuously, without returns.

According to the data, over the past 75 years, the amount of humus in the fertilized variant increased from 1.24% to 1.64% in different years and norms, while in the N P K given variants the initial amount of humus was maintained. The amount of humus was reduced in the options where no fertilizer was applied or a portion of mineral fertilizers (PO 56 kg / ha, KO 90) was applied. The amount of nitrogen in the soil is related to the humus in the soil, and the addition of manure to the soil led to the preservation of the amount of nitrogen [15].

It can be concluded that the amount of humus and nitrogen in the soil varies over many years when a crop is planted without fertilizer, with fertilizers and crop rotation, their subordination to different laws depends on soil and climatic conditions, soil mechanical composition and farming system.

2 Materials and methods

This experiment related to study the fertility of the soil is carried out in the conditions of the old irrigated soils of Tashkent region, which are irrigated from the past, with a mechanical composition of medium sand, groundwater at a depth of 18-20 meters. The duration of the experiment is 96 years and is carried out without repetitions. The experiment consists of a total of 8 options, option 1 monoculture consisted of 30 t / ha fertilizer per hectare + 30 kg / ha phosphorus per year, option 2 monoculture was N P K 250:175:125 kg / ha annually, option 3 monoculture was absolute fertilizer-free, control, option 4 monoculture was N P K 150:100:50 kg / ha, annually, option 5 was 3:7 alfalfa-cotton crop rotation and N P K 150: 100: 50 kg / ha, option 6 was 3:7 alfalfa-cotton crop rotation and N P K 150:100:50 kg / ha + 30 t / ha fertilizer, option 7 was 3:7 alfalfa-cotton crop rotation without fertilizer, control, 3:7 alfalfa-cotton crop rotation + 10 t / ha manure year interval. The area of each option is 2000 m2, the total area is 1.6 hectares.

The volume mass of the soil and the amount of humus in it at the beginning and end of the application period were determined from all variants in 0-30 and 30-50 cm layers of soil, volume mass was determined in Kachinsky, humus content in Tyurin methods. Calculations in tons of humus in the soil were based on the weight (mg) of soil in 1 cm cube in a 0-30 cm layer of soil based on a unit of area volume.

3 Results and discussion

Improving soil fertility has always been a topical issue and a major problem in agriculture. Typically, field experiments lasting more than 50 years are long-term experiments [12]. The scientific results obtained in these experiments differ markedly from the scientific results obtained from conventional experiments in that they are important in that they are mutually compatible and systematically interrelated. Long-term field experiments provide monitoring of the amount of humus, nutrients and microorganisms in the soil and their interaction, the dynamics of soil contamination with heavy metals, various toxic and hazardous substances for humans and the biosphere. Also, long-term experiments provide wide range of options to draw in-depth scientific conclusions on biological, agrochemical and agro-physical processes occurring in the soil that cannot be detected in short-term experiments [13].

The experiment conducted on the theme "Soil fertility in continuous cotton and crop rotation fields" at the Scientific Research Institute of Cotton Breeding, Seed Production and Agrotechnology from 1926, for 96 years founded by A.S.Makarov, its first performer was P.V. Starov. Later as the main performers of the experiment were I.A.Dorman, F.A.Sokolov, V.G. Berezovsky, P.M. Bodrov, Z.S. Tursunkhodjaev [14, 15], A.S .Bolkunov, V.E.Kurochkin, B.M.Khalikov [16].

In this article, we present three experiments that have been carried out continuously for 96 years, variant 1, which uses 30 t / ha of manure + 25 kg / ha P2O per year, variant 2, which annually uses the norm of mineral fertilizers NPK 250:175:125 kg / ha, and without fertilizer, an analysis of the data obtained from control option 3 is given.

According to the analysis of the obtained data, in the first year of the experiment, the initial amount of humus in the 0-30 cm layer of soil was 1.84% in variant 1 or 68.45 t / ha (after 30 tons of manure), 1.42%; 53.25 t / ha in options 2 and 3, respectively. After 20 years (1946) the amount of humus decreased in option 1 by 0.009% or 0.335 t / ha, in option 2 by 0.173% or 6,487 t / ha, and in option 3 decreased by 11.40 t / ha or 0.304%, respectively; decrease in humus by variants was also observed in the following years of the experiment, and after 40 years the indicators for variants 1, 2, 3 were 0.099% -3,683 t / ha, 0.146% -9,225 t / ha; 0.439% -16.46 t / ha, respectively, 0.307% -11.40 t / ha; 0.349-10.09 t / ha; 0.508% -19.05 t / ha after 60 years; after 80 years, While decreased to 0.665% -24.441 t / ha; 0.452% -16.95 t / ha; 0.701%-26.29 t / ha, so far these figures have been decreased by 0.876% -32.588 t / ha, 0.524% -19.65 t / ha; 0.778% -29.17 t / ha in the options.

Table 1. The amount of humus in the fields where cotton is grown continuously decrease relative to the initial amount, %, t / ha, (in layers of 0-30 cm).

Options	Initial humus content, (1926 y)			After 20 years, (1946 y)			After 40 years, (1966 y)			After 60 years, (1986 y)			After 80 years, (2006 y)			After 96 years, (2022 y)			Decrease in average a year	
	%	t/ha	%	%	t/ha	%	%	t/ha	%	%	t/ha	%	%	t/ha	%	%	t/ha	%	%	t/ha
Annually 30 t / ha manure + 25 kg / ha P2O	1.84	68.45	100	0.009	0.335	0.4	0.099	3.683	5.3	0.307	11.40	16.6	0.655	24.44	35.7	0.876	32.588	47.5	0.49	0.33
N P K 250:175:125 kg / ha	1.42	53.25	100	0.173	6.487	12.2	0.146	9.225	17.3	0.349	10.09	18.9	0.452	16.95	31.8	0.524	19.65	36.9	0.38	0.20
Fertilizer-free (control)	1.42	53.25	100	0.304	11.40	21.4	0.439	16.46	30.9	0.508	19.05	35.7	0.701	26.29	49.3	0.778	29.17	54.3	0.56	0.30

The analyzed the results shows that the highest decrease in the amount of humus in the soil over the years was observed in the fertilizer-free variant, the amount of humus after 20 years was decreased by 21.4% or 11.4 t / ha compared to the initial amount, after 40 years, it was 30.9% or 16.46 t / ha, 35.7% or 19.05 t / ha after 60 years, 49.3% or 26.29 t / ha after 80 years, and 54.3% or 29.17 after 96 years. This figure is determined a decrease by 12.2% - 6,487 t / ha, 17.3% -9,225 t / ha; 18.9% -10.09 t / ha; 31.8% -16.95 t / ha; 36.9% -19.65 t / ha, respectively, for years in variant 2, where the norm of mineral fertilizers was applied annually N P K - 250:175:125 kg / ha; a decrease of was found 0.4% -0.335 t / ha; 5.3% - 3,683 t / ha; 16.6% -11.40 t / ha; 35.7% -24.44 t / ha; 47.5% -32.58 t / ha in option 1 where 30 t / ha of manure + 25 kg / ha P2O was applied annually. It can be seen that the highest rate of humus reduction for 96 years was observed in the control variant (54.3%), while in option 1, which applied 30 t / ha of manure + 25 kg / ha P2O per year, by 47.5%, N P K - 250:175: 125 kg / ha norm used in variant 2 per year was reduced by 36.9%.

Hence, the use of nitrogen, phosphorus and potassium fertilizers in plant care serves to maintain the relative amount of humus in the soil.

It should be noted that the dynamics of humus decrease varied in the options. In Option 1, where 30 t / ha of fertilizer + 25 kg / ha of P2O was applied annually, the decrease in humus content was very slow in the first 60 years (decreased by 11.40 compared to the initial amount in 60 years), and a sharp decrease (35.7% in 80 years, 47.5% in 96 years) was detected. In option 2, where the N P K - 250: 175: 125 kg / ha norm was applied annually, the humus content was reduced steadily (5-10% every 20 years), while in the fertilizer-free, control option, the humus content decreased sharply in the first 20 years (21.4%), the decrease was observed to be from 5% to 14% in the twenties. Thus, the decomposition of manure in typical sierozem soils was slow in the first 50-60 years and then could be increased in recent years due to rising temperatures and improved agro-technical measures in plant cultivation (use of two-tiered plows and plowing depth).

In addition, the average annual reduction of humus was 0.49% -0.33 t / ha in option 1, where 30 t / ha of manure + 25 kg / ha P2O was applied annually, and the rate of N P K - 250:175:125 kg / ha was applied annually. In variant 2, it was found to be 0.38%-0.20 t / ha, and in the fertilizer-free control variant 0.56%-0.30 t / ha. Apparently, the difference between Option 1 and Option 3 of the experiment is not large. It can be concluded that a large part of the humus formed from the manure applied to the soil goes to the formation of the cotton crop.

4 Conclusion

1. From this long years standing experiment, the data obtained on the production capacity of typical sierozem soils and the conclusions and recommendations based on their analysis serve as a starting material for assessing, restoring, maintaining and increasing soil fertility in certain soil climates. It also provides invaluable information on soil microflora, ecology, activity of soil microorganisms.

2. The application of nitrogen, phosphorus and potassium fertilizers in plant cultivation under typical sierozem soil conditions maintains the relative amount of humus in the soil.

3. Applying 30 t / ha of manure to the soil every year for many years will not reduce the amount of humus in the soil for 50-60 years.

4. Rising air temperature and improvement of agro-technical measures in plant cultivation (use of two-tiered plows in plowing and plowing depth) accelerate the process of humus decomposition in the soil.

5. Most of the humus formed from manure applied to the soil is used for the formation of cotton yield.

References

1. O. Y. Voronkova, A. M. Zadimidcenko, L. V. Goloshchapova, A. G. Polyakova, S. G. Kamolov, E. M. Akhmetshin. Economic and mathematical modeling of regional industrial processes. European Research Studies Journal, **21(4)**, 268-279 (2018). doi: 10.35808/ersj/1119
2. E. M. Akhmetshin, A. V. Plotnikov. Sentiment analysis of client reviews of the russian agricultural bank service and predicted rating reviews. Paper presented at the IOP Conference Series: Earth and Environmental Science, **548(2)**, (2020). doi:10.1088/1755-1315/548/2/022042
3. M. Kerimov, V. Smelik, M. Kerimov, M. Volkhonov, V. Kukhar. Nanotechnologies in agricultural engineering: practice and prospects, E3S Web of Conf., **222**, 01022 (2020). doi: 10.1051/e3sconf/202022201022
4. E. Kirillova, I. Otcheskiy, S. Ivanova, R. Karlibaeva, V. Sekerin. Developing Methods for Assessing the Introduction of Smart Technologies into the Socio-Economic Sphere Within the Framework of Open Innovation. International Journal of Sustainable Development and Planning, **18(3)**, 693-702 (2023).
5. S.Tynybekov, R.Yerezhepkyzy, A.K.Berdibayeva, A.A.Esekeeva, N.K.Mynbatyrova, E.Akopova. Access to environmental information in legislation of the republic of Kazakhstan, Life Science Journal, **11(spec. issue 5),** 231-238 (2014). doi:10.7537/marslsj1105s14.45
6. K. Kunanbayev, G. Churkina, V. Filonov, M. Utebayev, I. Rukavitsina. Influence of Cultivation Technology on the Productivity of Spring Wheat and the Humus State of Southern Carbonate Soils of Northern Kazakhstan, Journal of Ecological Engineering, **23(3),** 49-58 (2022). doi: 10.12911/22998993/145459
7. O. Tsuglenok, M. Abushenkova, R. Akhmadeev, K. Tyupakov. Cluster as the basis for the sustainable functioning of enterprises in the agro-industrial complex. Siberian Journal of Life Sciences and Agriculture, **15(1)**, 416-434. (2023). doi: 10.12731/2658-6649-2023-15-1-416-434
8. G. Balaji, P. Vijayakumar. Big data application in the Neyman-Pearson regression and deep bernoulli and boltzmann for iot based soil quality prediction. Siberian Journal of Life Sciences and Agriculture, **14(1)**, 262-285 (2022). doi: 10.12731/2658-6649-2022-14-1-262-285
9. B. M. Khalikov. Influence of permanent sowing of cotton on soil fertility. Scientific and practical journal AGRO XXI, Moscow, **1-3**, p.18-19 (2006).
10. M. A. Mazirov. Long-term field experience of RGAU-MSHA: essence and stages of development. RGAU-MSHA named after K.A. Timiryazeva, Moscow, 153-160 (2010).
11. M. A. Mazirov, V. A. Arefieva. A brief review of the results of scientific research in the world's long-term field experiments. Theoretical and technological bases for the reproduction of soil fertility, productivity of agricultural crops. Proceedings of the International Scientific and Practical Conference. Russian State Agrarian University of the Moscow Agricultural Academy named after K.A. Timiryazev. Moscow, 22-31 (2012).
12. B. A. Dospekhov, *Methods of field experiments* (M.: Kolos, 1979) 415.
13. K. Barmuta, N. Tuguz. Organizational and Managerial Mechanism for Risk Management of Agricultural Enterprises. E3S Web of Conferences, **273**, 08005 (2021).
14. Z. S. Tursunkhodzhaev, M. A. Sorokin, A. L. Toropkina. Productive capacity of sierozem soils in crop rotation and cotton monoculture (Publishing house "FAN",

Tashkent, 1977) 95.

15. Z. S. Tursunkhodzhaev, A. Bolkunov, *Scientific basis of cotton crop rotations,* (Tashkent, "Mehnat", 1987) 149.
16. B. M. Khalikov, F. B. Namozov, *Scientific basis of crop rotation* (Tashkent, “Noshirlik yog’dusi”, 2016) 222.