Assessment of the humus state of hortically suitable soils Northwest Caucasus

Alexander Osipov[1*], *Valery* Slyusarev[1], *Tatiana* Shvets[1], and *Anton* Gritsenko[1]

[1]Kuban State Agrarian University, 13, St. Kalinina, Krasnodar, 350044, Russia

Abstract. The laying of intensive industrial gardens in Russia is carried out according to special projects, which are based on complex works that begin the selection and assessment of the soil suitability of land plots. The levels of total humus and its labile forms have been established for the main horticultural soils of the Krasnodar Territory on the basis of long-term studies. The use of these criteria makes it possible to assess the degree of cultivation or degradation processes of the soil cover of each specific garden plot. Studies have shown that, in all surveyed soils of the region, the profile distribution of humus is gradually decreasing. The most informative soil layer for assessing fertility can be considered the upper 30 cm layer. The greatest quantitative and qualitative changes of organic matter occur in this layer. Different gardening zones of the region differ in the content of total humus in the main types of soils, a decrease is observed from ordinary chernozems (northern zone) to alluvial meadow soils (river valleys of the foothill zone). The humus content in the natural cenoses of Kuban chernozems reached 5.5 %, and in heavily plowed soil up to 3.5 %, a similar situation was observed in floodplain soils, these values corresponded to 4.0 % and 2.0 %. All other types of soils occupied an intermediate position in terms of humus content.

1 Introduction

The long period of growth of fruit crops in one place is one of the main specific industry features of horticulture. Impressive funds are spent on laying gardens and caring for them, which, under optimal conditions of growth and development of fruit plants, quickly pay off and throughout the entire period of growth of fruit plantations contribute to high economic efficiency [5, 7].

According to their biological characteristics, fruit crops are the most demanding to growing conditions, and some of them, in turn, differ in a variety of reactions to a complex of natural factors.

In this regard, the selection and qualitative assessment of land for gardens is a rather difficult and responsible task, in solving which it is necessary to simultaneously take into account a whole range of conditions. During the solution of this task, the requirements of fruit plants for soil conditions and the need to prevent and eliminate the developing processes of soil erosion are necessarily taken into account (in a number of zones, land

* Corresponding author: kubsoil@mail.ru

plots used for fruit crops are subject to more intensive destruction by water erosion processes), economic and organizational features of land users, selection of the best soil conditions for each crop, first of all, and, if necessary, a varietal selection of crops [3, 9].

During observations during the laying of the garden, practice shows that mistakes are made when choosing land for gardens, which are practically impossible to eliminate in the future by any agrotechnical, reclamation or other measures.

Currently, the laying of intensive industrial gardens in Russia is carried out according to special projects, its basis is comprehensive work on the selection and qualitative assessment of land plots.

In the Krasnodar Territory, the zonality of various types of soils is clearly expressed. The main soil varieties that are used for planting fruit plantations are represented in the flat part of the region by chernozems – ordinary, typical, leached, in the foothill zone – gray and brown forest (slope) soils, in valleys and floodplains of rivers – alluvial meadow and meadow soils [4, 10].

Each type of soil has certain complexes of agrophysical properties and agrochemical indicators that differ from each other. Different intensity of anthropogenic impact on the soil leads to changes in fertility parameters. For the rational management of agricultural production, it is relevant to assess the soil fertility of each specific site. It is believed that the content of organic matter (humus) in the soil can serve as a complex indicator characterizing soil fertility. This is due to the fact that humus determines the physical properties of soils, their absorption capacity, and has a direct effect on air, water, nutrient, and even thermal regimes.

In conditions of intensive agriculture, with frequent tillage, increased mineralization of soil organic matter is observed [2, 6]. The consequence of this is the deterioration of the main parameters of soil fertility. Not only the indicators of the total humus are changing, but also its qualitative composition. Soils have lost the most useful labile part of humus for plants, which makes up about 30% of the total humus [3, 12].

2 Materials and methods

The purpose of our research was to establish the parameters of the humus state characterizing the degree of reproduction or degradation of soil fertility.

The methodological basis for solving this goal was the development of the V. V. Dokuchaev Soil Institute [8]. To assess the parameters of each type of soil, it is proposed to establish criteria such as the minimum, economically optimal and maximum content of total humus, as well as the content of its labile forms. These indicators should be entered in the passport of each surveyed land plot. The degree of degradation or reproduction of soil fertility is characterized by such relatively simple indicators as the excess of the actual level of humus content over the minimum and the degree of reproduction of humus, i.e. by the content of its most active labile forms [1, 11].

Using the knowledge gained and accumulated experience on this issue, we set the task of assessing the quality of humus of the main horticultural soils of the Krasnodar Territory at different intensities of their use under gardens and establishing on this basis indicators characterizing the degree of their cultivation. Biological features of fruit crops, such as long-term, permanent growth in a permanent place, features of soil technology have a significant impact on soil formation processes in garden agrocenoses and ultimately lead to significant changes in soil fertility. This determined the need to develop indicators directly for horticultural agrocenoses.

The objects of research to establish the level and content of humus and its labile forms were the garden quarters for the study of soil maintenance methods. The plantings are located in different areas of the region in typical points for each soil difference. In each

zone, according to the recommendations of the Soil Institute, soil was selected and analyzed from plots with different levels of fertility:

- After a long period of at least 8 years of steam treatment without applying organic fertilizers (heavily plowed soil).
- When applying organic fertilizers in doses compensating for the mineralization of humus with a dose of application (8-10 t/ha annually).
- When replenishing the soil with organic matter in doses exceeding compensating ones (areas with various ways of using perennial grasses).
- With a restored humus state (areas with constant natural cenosis under woody vegetation).

Soil samples were taken from a depth of 0-30 cm in the surveyed territories and soil analyses were performed for the content of total humus and the content of its labile forms.

3 Results and Discussion

The selection of sites for each type of soil with different fertility allowed us to establish the levels of their provision with humus and its labile forms (Table 1). The parameters of the humus state of heavily plowed soil without the application of organic fertilizers were attributed to a low level of content. In this case, the content of the total humus corresponds to the criterion of "minimum" content. This level of organic matter in the soils of the garden agrocenosis was noted, as a rule, during the age period of fruit crops (according to P. G. Shitt) "growth – fruiting", i.e. in the plantations entering the fruiting period.

Table 1. Levels of availability of humus and its labile forms of the main horticultural soils of the Krasnodar Territory (layer 0-30 cm).

Security levels	Chernozems			Grey and brown forest soils	Alluvial meadow and meadow soils
	ordinary	typical	leached		
General humus, %					
Low	<4.0	<3.5	<3.5	<3.0	<2.5
Average	4.0–5.0	3.5–4.5	3.5–4.5	3.0–3.5	2.5–3.0
Tall	>5.0	>4.5	>4.5	>3.5	>3.0
Labile forms of humus, $C_{org.}$, mg/1 kg of soil					
Low	<350	<400	<800	<1400	<1500
Average	350–450	400–500	800–1100	1400–1500	1500–1800
Tall	>450	>500	>1100	>1500	>1800

The levels of total humus and its labile forms in the soil receiving organic matter in doses compensating (or slightly exceeding) its mineralization were taken as average. We believe that the upper limit of this gradation can be taken as an "economically optimal" level.

The level of humus and its labile forms of natural cenosis (with a restored humus state) was taken as the "maximum".

Since the profile distribution of humus is gradually decreasing in all the surveyed soils of the region, the top layer of 30 cm can be considered the most informative soil layer for assessing fertility. The greatest quantitative and qualitative changes of organic matter occur in this layer.

The organic matter accumulating in the soil reaches a constant level characteristic of each type of soil. Therefore, in zonal terms, the content of total humus in the main types of horticultural soils of the Krasnodar Territory was different and decreased from ordinary chernozems (northern zone) to alluvial meadow soils (river valleys of the foothill zone). So, if in the natural cenosis the humus content in ordinary chernozem reached 5.54 %, and in

heavily plowed soil 3.50 %, then in alluvial meadow soil, these values are equal to 4.0 % and 2.0 %, respectively. All other types of soils occupied an intermediate position in terms of humus content.

If the content of total humus indicates the potential fertility of soils, then the content of its labile forms shows its effective fertility at the moment. When extracting labile forms of humus with various recommended extracts, we came to the conclusion that the extraction of 0.1n with sodium hydroxide solution was the most informative for the soils of the region. The level of content of labile forms of humus in the soils of various zones has a reverse course in comparison with the content of total humus (Table 1).

This is due to the varying degree of their fixation by the mineral part of the soil. Thus, in chernozem soil types, alkaline extraction extracts up to 2 % of carbon from its total content, whereas in younger alluvial meadow and meadow soils – up to 16 %. It should be noted that in the soils of the foothill zone of the Krasnodar Territory, the maximum amount of labile forms of humus was extracted not from soils of natural cenoses, as noted in the soils of the flat part of the region, but from soils treated and receiving high doses of organic substances. Apparently, the higher enrichment of these soils with organic matter in conditions of natural cenosis contributes to the better consolidation of its labile forms. The data obtained indicate a significant mobility of humic substances in the soils of the foothill zone, and the need for regular replenishment with organic matter.

A feature of agricultural technology in horticulture is also the need for deep tillage (planter plowing) before planting. Such treatment may slightly change the situation of the distribution of organic matter along the soil profile. In this case, an indicator such as humus reserves in the soil profile per unit area can be used to characterize the potential fertility of soils. According to the research data, humus reserves were calculated for each type of soil with a contrasting degree of cultivation (Table 2).

Table 2. Reserves of organic matter in the main horticultural soils Krasnodar Territory (in layers 0-30 / 0-100 cm, t/ha).

Soil type	Natural cenosis	Heavily plowed soil	Losses, %
Chernozems:			
ordinary	126 551	80 345	36.5 37.4
typical	123 540	75 390	39.0 27.8
leached	136 490	91 395	31.6 19.4
Grey and brown forest soils	134 420	51 186	61.9 55.7
Alluvial meadow and meadow soils	134 336	61 206	54.5 38.7

Humus reserves in the main types of horticultural soils of the region were different, at the natural cenosis the highest values in the 30 cm layer were observed in leached chernozems (136 t/ha), in the meter thickness this indicator is high in all chernozem subtypes (490-551 t/ha). The same trend persists in heavily plowed chernozem soils. Low humus reserves on heavily plowed soils were observed in gray and brown forest soils, in the 0-30 cm layer it was only 51 t/ha, and in the meter thick – 186 t/ha.

4 Conclusion

Thus, as a result of the conducted studies, the levels of total humus and its labile forms were established, the ratio of which can be used to judge the degree of reproduction or

degradation of the soil. It is necessary to evaluate the fertility of each specific soil only according to the criteria established for this type. Those parameters of the humus state that are minimal for one type of soil will be optimal for another, or even maximum, at which the soil is capable of yielding high yields.

In the process of agricultural use of soils, in comparison with natural cenoses, losses of organic matter in the arable layer of chernozems amount to 32-39 %, in the soils of the Foothill zone – 54-62 %. This fact indicates the different rates of mineralization and humification of organic matter in the studied soils and determines the issues for further study. The high degree of mineralization of organic matter in the conditions of the Foothill zone makes soils very vulnerable and sensitive to processing methods. This determines the need to develop appropriate methods of soil maintenance in fruit plantations.

References

1. A.R. Barzegar, A. Yousefi, A. Daryashenas, The effect of addition of differ-ent amounts and types of organic materials on soil physical properties and yield of wheat, PlantandSoil, **247**, **2**, 295–301 (2002)
2. O.S. Bezuglova, Humus state of soils in the south of Russia, Rostov-on-Don, 228 (2011)
3. V.P. Vlasenko, A.V. Osipov, V.N. Slyusarev, Diagnosis of human-induced degradation of soils of the Azov-Cuban lowland, In the collection: E3S Web of Conferences, "1st International Scientific and Practical Conference "lnnovative Technologies in Environmental Engineering and Agroecosystems", ITEEA 2021" (2021)
4. V.P. Vlasenko, V.I. Terpelets, A.V. Osipov, Modern classification of hydrometamorphosed soils of the Northwestern Caucasus, Proceedings of the Kuban State Agrarian University, **38**, 72–77 (2012)
5. E.V. Kravchenko, I.V. Budagov, E.Bondarenko, On the state and use of land resources of the Krasnodar Territory, Science, technology, Technologies (Polytechnic Bulletin), Krasnodar, **4**, 60–66 (2014)
6. X. Liu, S.J. Herbert, A.M. Hashemi, X. Zhang, G. Ding, Effect sofagricultural management on soil organic matter and carbontrans formation – areview, Plant, Soiland Environ, **12**, 531–543 (2006)
7. V.P. Popova, T.N. Vorobyova, T.G. Fomenko, Management of reproduction of soil fertility of fruit and grape cenoses: monograph (SKZNISIV, Krasnodar, 2016)
8. K.V. Dyakonova, Recommendations for the study of the balance and transformation of organic matter in agricultural use and intensive cultivation of soils, V. V. Dokuchaev Institute, Moscow, 96 (1984)
9. V.N. Slyusarev, L.N. Onishchenko, The current state of soils in the North-Western Caucasus, Proceedings of the Kuban State Agrarian University, **42**, 99–103 (2013)
10. V.N. Slyusarev, T.V. Shvets, A.V. Osipov, Soils of the Krasnodar Territory : textbook (KubGAU, Krasnodar, 2022)
11. T.V. Shvets, Soil fertility of the Lowland-Western agricultural landscape of the Azov-Kuban lowland in the cultivation of agricultural crops, Dissertation for the degree of Candidate of Agricultural Sciences, Kuban State Agrarian University, Krasnodar (2009)
12. V.S. Tskhovrebov, Changes in the content of organic matter of chernozems of the Central Caucasus, Agrochemical Bulletin, **4**, 18-20 (2005)