Ss. Cyril and Methodius University in Skopje
Faculty of Agricultural Sciences and Food - Skopje

Institute of Environment
Department of Soil Sciences
Accreditation laboratory for soil and fertilizers analysis L-04

PEDOLOGY REPORT
FOR CONTROL OF SOIL FERTILITY

FOR K.P. 3149/1 IN Municipality Kriva Palanka

(Municipality of Kriva Palanka, St Joachim Osogovski street 175, 1330 Kriva Palanka)

ПРОЕКТ: PARKS 01-011

Interreg (VI-A) IPA Bulgaria - North Macedonia 2021-2027 Programme Priority 1 Greener Border Region
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PARTICIPANTS IN THE PRODUCTION OF THE STUDY

Based on your request with arch. no. 09-6/640 of 19.8.2024 We are submitting the PEDOLOGY REPORT FOR CONTROL OF SOIL FERTILITY FOR K.P. 3149/1 IN Municipality Kriva

PALANKA by project PARKS 01-011 Interreg (VI-A) IPA Bulgaria - North Macedonia 2021- 2027 Programme Priority 1 Greener Border Region (ref. No 2021TC16IPCB006 – 2023-3). BC4grant contract RD02-29-43501.07.2024.

The accredited laboratory for the analysis of soil and fertilizers L-04, based on your request, we deliver the pedological report.

They participated in the preparation of the report on soil fertility control. Department of Soils:

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The report on soil fertility control refers to K.P. 3149/1 IN Municipality Kriva Palanka

Head of Soil and Fertilizer Laboratory (L-04)	**DEAN**
Prof. Dr. Mile Markoski	**Prof. Dr. Mile Markoski**

INTRODUCTION

The soil, together with the atmosphere and the hydrosphere, is an integral part of the environment and represents the most precious natural resource without which human, plant and animal life is impossible. Although it represents only a small part (layer) of the lithosphere (the Earth's crust), it really represents life, providing one of the conditions for food production. Although the application of pedology is multifaceted, for us it is of greatest interest its application in agriculture because the soil is a basic factor for the production of biomass (food). Only with a good knowledge of the soils and their constant research, many agrotechnical and amelioration measures (table 1), known today as good agricultural practice (DZP), can be successfully implemented. With the correct application of these measures, it is possible to increase the fertility and productive capacity of the soil, thereby providing conditions for the realization of high, stable and quality yields from cultivated agricultural crops.

Table 1. Agrotechnical and amelioration measures

Agrotechnical measures	Remedial measures
➢ proper processing	➢ fight against erosion
➢ proper crop rotations	➢ field reclamation
➢ correct use of mineral fertilizers	➢ change of the mechanical composition
➢ proper use of pesticides	➢ humanization
➢ mulching and snow retention	➢ hydrotechnical improvements
➢ strengthening of microbiological processes	➢ desalination, dealkalization, calcification
	➢ meliorative fertilizing with mineral fertilizers
	➢ ameliorative processing
	➢ decontamination
	➢ building more protective forest belts

Functions and basic characteristics of the soil

Soil has numerous ecological functions that are essential for the environment, but also for the economy and progress of society as a whole. As a dynamic polydisperse system with many functions, soil provides support for the entire ecosystem.

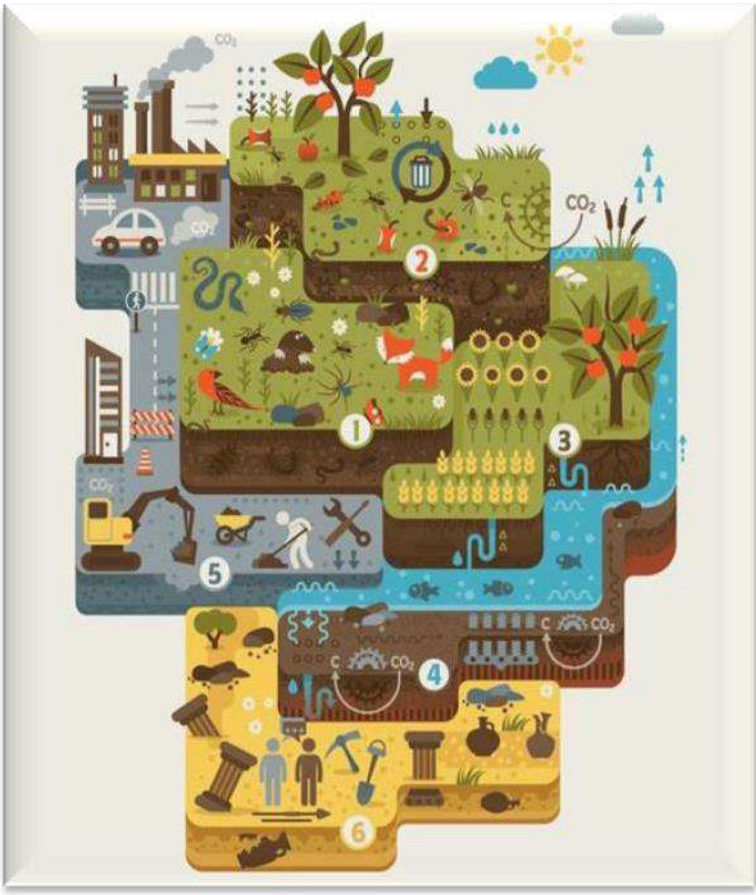


Figure 2. Soil functions

- **The most important function of the soil is the production of biomass (food).**
- **Soil is part of the large (geological) and small (biological) circular movement of matter and energy in nature and plays a significant role in it..**
- **Soil also plays a significant role in the hydrological cycle (the movement of water) in nature. The soil receives, retains, conducts and releases water. Part of the water that is retained is significant for the water supply of the plants.**
- **The soil is a home and habitat in which a large number of representatives of the micro and macro fauna live and act. It is a genetic reservoir (a quarter of global biodiversity), much larger than water and air.**.
- **Soil is a reservoir (guardian) of organic carbon and has a major role in climate change.**
- **The soil is a purifier (recycler) of the environment. It retains and transforms many harmful substances that come from other components of the environment (water, air...) and are mostly a product of human activities**.
- **The soil is a platform for the construction of various objects.**
- **The soil is a geological and cultural heritage, a part of the landscape, and it holds many archaeological artifacts and paleontological materials, which speak about the history of man and the evolution of the living world.**

- **The soil changes the atmosphere. In places where the soil is dry, without vegetation and with a destroyed structure under the influence of the wind, the lifting of soil particles (dust,sand...) and their increased presence in the air, the atmosphere can occur. This can reduce visibility and pose a health hazard to people as a result of breathing dirty air. Conversely, moist and structured soils can prevent such dust-enriched air. Evaporation of moisture from the soil is a source of water vapor in the atmosphere, thus causing changes in air temperature. By "breathing" the soil, the composition of the individual gases between the soil and the atmosphere also changes, with some of them affecting the global warming of the Earth.**

- **- Finally, the soil has a significant recreational function**.

For the agricultural producer, the soil, together with the atmosphere, represents the environment in which the plant lives and yields. It should provide the root system with all the conditions necessary for its life. The height and quality of the yields from cultivated crops depends a lot on how the soil performs its role. High and stable yields can be obtained only if crops are provided with all factors simultaneously, without interruption during the entire vegetation and in the optimally required quantities, aligned with the stages of plant development.

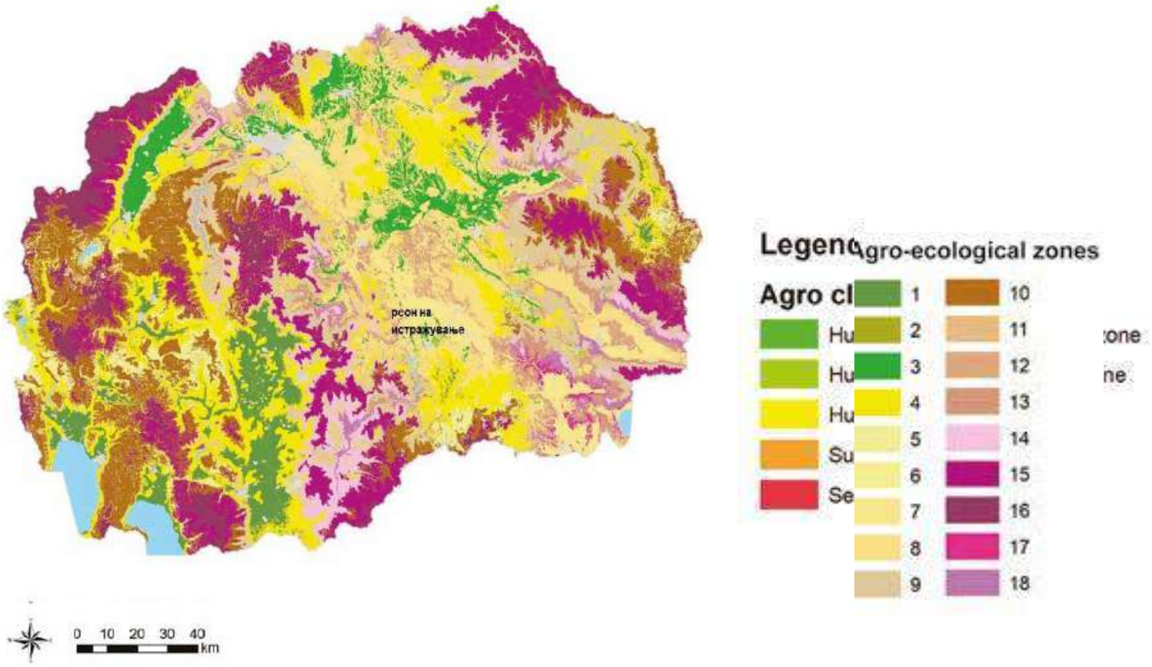
In agricultural production, the soil is also a product of labor. In it, man applies various agrotechnical and remedial measures in order to create optimal conditions for the cultivated plants. Without a good knowledge of the soils, not a single agrotechnical and meliorative measure can be applied, and at the same time it is not possible to make a correct choice of crops that will be successfully grown according to the conditions of the field.

The mistakes made in the application of these measures, due to the ignorance of the soils, can be catastrophic, because they require large investments with effect for a longer period. Here's why: Before irrigating or draining some terrains, the soils are well studied beforehand. It is necessary to know what kind of soils will be obtained by drainage, what effect the irrigation will give, what changes it can cause in the soil, etc.

Fertilization with mineral and other fertilizers is successfully applied only in conditions when the soils have been previously studied and the need to add individual nutrients has been established.

Without a good knowledge of the soils, a correct system of cultivation cannot be applied. The deepening of the plow, the correct selection of the moment for cultivation, the quality of cultivation and the resistance that the soil gives during cultivation, and in connection with it the necessary traction force and fuel consumption, are in the closest relationship with the properties of the soil.

LOCATION OF THE RESEARCHED AREAS OF K.P. 3149/1 IN Municipality Kriva Palanka.



1. FACTORS ON WHICH AGRICULTURAL PRODUCTION DEPENDS

Obtaining high and quality yields in agriculture depends on the following factors: light, heat, water, food and air. These basic factors can include mechanical support and the absence of inhibitory substances, i.e. to those that reduce or prevent the growth of agricultural crops. With the exception of light, all other factors fully or partially act through the soil and therefore, yields depend

to the greatest extent on the fertility of the soil, that is, on how it provides the crop with all those conditions. Hence the great interest of agricultural producers in controlling soil fertility and its properties.

It is wrong to think that the soil is fertile if it contains only a certain amount of physiologically active nutrients. Soil fertility implies the ability of the soil to supply cultural plants throughout the vegetation, without interruption, and in the required quantity with food, water, air and other necessary conditions. The ultimate goal is obtaining high, stable and quality yields, so another term is important, namely soil productivity, the measure of which is the height and quality of the yields. The height of yields is a function of soil fertility, climate, plant and human influence.

Fertilization is one of the most important factors for obtaining a high and quality yield for all agricultural crops. Only with proper nutrition of the plants can the full expression of the genetic potential of the fertility of the varieties be achieved, thereby achieving the maximum yield and desired quality. In agricultural production, the proper nutrition of plants, which is achieved by fertilization, can represent 30-70% of all factors affecting the production process. However, in order to take certain measures to increase the yield and its quality through the use of fertilizers, it is necessary to know the needs of the crop for nutrients, the total amount of nutrients in the soil and their amount available to plants. Based on these data and knowledge, appropriate doses of fertilizers are recommended, which are reasonable and on the one hand contribute to achieving a high and quality yield, and on the other hand take into account the protection of the environment,

i.e. soil, water and air.

An integral part of fertilizing must be the use of organic fertilizers such as manure, vegetable waste and compost. The intake of organic fertilizers can significantly contribute to the long-term improvement of soil fertility, in terms of its physical and chemical characteristics.

For the proper growth and development of plants, the presence of a sufficient amount of macroelements and microelements in the soil that are available to plants is necessary. To be clear, Table 1 presents the level of nutrients in the soil and the degree of phosphorus and potassium fertilization needs.

Before introducing an additional amount of nutrients into the soil, it is necessary to make a soil analysis and through it to determine the presence of nutrients in the soil in a certain arable area. Entering amounts of nutrients greater than necessary for a given crop not only unnecessarily increases production costs, but can lead to a decrease in the yield and quality of fruits, the

appearance of toxicity and blocking the reception of other nutrients, thus and their deficiency for plants.

Table 2. Level of nutrients in the soil and degree of needs from fertilization with phosphorus and potassium

Tag on the level	Rating of the level	Content in the soil [mg/100g]		Need for fertilization with P_2O_5, K_2O	Return of P_2O_5, and K_2O from the above [%]
		P_2O_5	K_2O		
A1	Very low (ameliorative)	< 5	< 5	Remedial fertilizing (+100-200% more than what was brought out)	100
A2	Low	5-10	5-10	Much increased fertilization (+30-50% more than what was brought out).)	80-90
A3	Medium	10-15	10-15	Moderately increased fertilization (+10-30% more than applied)	60-70
A4	Optimally	15-25	15-25	Maintenance fertilization only (only the amounts of R and K returned)	50-60
A5	High	25-40	25-40	Moderately discounted (returns 20-30% less than what was taken out)	30-40
A6	Very high	40-50	40-50	There is no need for fertilization (fertilization is omitted for 1-3 years by controlling the level of microelements)	To be left out application 1-3 years
A7	Harmful	>50	>50	There is no need for fertilization in a long period. Measures are implemented to protect against possible poisoning, strict control of microelements	To be left out application 3-5 years

FERTILITY AND PRODUCTIVITY OF THE SOIL

For proper growth and development and for obtaining high and quality yields from cultivated plants, several factors are needed, namely: light, heat, water, air, food (nutrients), mechanical support and the absence of inhibitory substances (factors). With the exception of the light factor, all the rest are fully or partially provided by the soil, while all factors are equally important, irreplaceable and should be constantly present in the soil to obtain high, quality and healthy yields. Hence, it can be concluded that soil fertility is a concept that includes all the previously listed factors. Fertility is a new quality property of the soil as a natural-historical body, which distinguishes it from compact rocks. Fertility is connected with the way of using the soil and obtaining yields from the cultivated plants. There are many definitions of soil fertility in the pedological literature. Among them, the most complex is the definition of

Filipovski (1993), according to which: Soil fertility is understood as its ability to supply cultural plants throughout their entire life (vegetative period), without interruption, simultaneously with the necessary amount of food, water , air and other necessary conditions. From the definition, it can be concluded that, in

pedology, soil fertility is viewed much more broadly, unlike some other disciplines, where soil fertility is associated only with its provision with a total amount of physiologically active substances (available nutrients). Several types of soil fertility are distinguished: » natural, » anthropogenic and

» effective fertility. Some authors mention potential, relative and economic soil fertility. Natural fertility, the name itself says that it represents fertility that the soil gets naturally as a result of its formation under the influence of pedogenetic factors and processes. So, during pedogenesis, unlike the substrate, the formed soil acquires three basic characteristics important for growing plants, namely: to retain water, air and nutrients. During the physical and chemical decomposition of the walls, a loose mass is formed that retains water and air, and with the chemical decomposition of primary minerals, soluble compounds of various biogenic elements, with the exception of nitrogen, are obtained, among other things. With this, conditions are created in the loose mass for the settlement of higher plants, which, together with other living organisms, are the main factor in the synthesis and decomposition of organic matter and in the small (biological) circular movement, which creates the organic part of the soil (organic waste, humus) and biogenic elements accumulate in the surface part of the soil. In all these processes, organisms accumulate large amounts of energy in the soil and enable the existence of future generations of plants and the entire ecosystem. Anthropogenic fertility is characteristic of agricultural soils and is created under the influence of man by taking appropriate agrotechnical and remedial measures. Anthropogenic fertility changes and depends on different human influences, whereby it can increase, but unfortunately, it can also decrease. Both together (natural and anthropogenic) make up the effective soil fertility. It is synonymous with soil productivity, according to Western European and American authors. Soil fertility as its quality property does not represent a constant size. It changes under the influence of various factors and processes that occur in the soil itself, but also in the immediate environment. In the literature, there is another term – productive capacity of the soil, which is related to the yields from cultivated plants. This means that for obtaining high and quality yields, in addition to the quality of the soil, the climatic conditions, the biological capacity of the plants and others are also important.

Productivity of the soil = the amount of yields = a function of the fertility of the soil, the climate, the plant and the action of man.

Soil fertility can have relative importance in relation to productive capacity. It can be explained with the following example: The same soil is not equally productive for every plant, in all climatic conditions and in all systems of agrotechnics. Especially in our climatic conditions, it should be emphasized that in areas where there is no irrigation system, despite all timely and correctly implemented agrotechnical and other measures, the productive capacity of the soil depends on the amount and distribution of precipitation coming from the atmosphere during vegetation, continue to have an impact on the water, air, heat and nutrient regime in the soil, and hence on the amount of yields from plants. In this context, the famous phrase "birth and non-birth years" is very often heard. Since the fertility of the soil is closely correlated with its physical, chemical and biological properties, as well as with the processes taking place in it, it means that soils with high fertility should meet some conditions and characteristics. Of the physical characteristics, of particular importance for fertility are: the depth of the physiologically active layer in which the roots of plants develop, then the mechanical composition, structure, porosity, physical- mechanical and water-air and thermal properties of the soil. Fertile soils have a deep physiologically active and loose layer in which the root develops easily, without any resistance during its penetration through the soil mass. Such soils are loamy in mechanical composition, with a stable granular structure and formed mostly on light loamy and clayey alluvial and deluvial sediments and lake sediments. In fertile soils, there is an optimal amount of physiologically active water, and with it, mobile available nutrients throughout the entire growing season. An important factor for high soil fertility is good porosity and aeration, as well as the presence of stable structural aggregates, which enable the soil to provide optimal amounts of air (oxygen) necessary for root respiration, pedofauna, aerobic microflora and for the intensification of processes of oxidation on which the availability of nutrients for plants depends. Of the physical characteristics, the favorable temperature regime for the development of all life functions of the plants and for the microbial, chemical and physical processes in the soil is significant for the fertility of the soil. Of the chemical characteristics, the following are of particular importance, directly or indirectly for soil fertility: the amount, composition and forms of humus, the reaction of the soil solution, buffering, the high capacity of adsorption with full dominance of adsorbed Ca2+ - ions, the high values of the redox potential , then the content of available forms of the necessary macro and microelements, stimulating substances for plants, as well as the absence of toxic substances. Ripe humus has a very positive effect on soil fertility. Its gradual mineralization allows the release of nutritious

biogenic elements important for plant nutrition. Most plants develop optimally in a weakly acidic to weakly alkaline reaction of the soil solution with the simultaneous absence of substances that in higher content have a toxic effect on them: H-, OH-, Al3+, Fe2+, Mn2+, and from gases: CH4, H2S, H2 , NH3, etc. One of the most important factors for soil fertility is the favorable nutrient regime, which implies a sufficient amount of all necessary elements in an available form, as well as their well-expressed dynamics and mobility. All this depends on the content of water, air, heat and activity of microflora and fauna in the soil. Fertile soils with good physical and chemical properties are also characterized by good biological properties. In them there is a sufficient number and representation of useful microflora, micro and macrofauna, whose activity affects the productive capacity of the soil. Also, fertile soils are characterized by the absence of inhibitory factors (impermeable compact horizon, presence of weeds, pests and diseases, toxic harmful substances, etc.). In agricultural soils, the agrotechnical and meliorative measures taken by man to maintain and increase soil fertility are of great importance. The ultimate goal of this is the creation of the so- called cultural soils that have a deep and loose arable layer, a stable granular structure, a favorable nutrient, water, air and heat regime, favorable chemical and microbiological properties and that are free of weeds, pests and diseases. The creation of cultural soils is a complex and complex work that requires a lot of knowledge, work and modern agrotechnical and amelioration measures, such as: » Timely and correct tillage of the soil, including deepening of the arable layer, as well as occasional shaking of the sub-arable layer, which possible occurrence of soil compaction, as a result of incorrect application of heavy machinery, is eliminated; » Improvement of the physical properties, especially of the structure of the soil and its stability, which simultaneously improves the water-air and thermal conditions of the soil; » Implementation of a correct system of fertilization with the introduction of mineral and organic (humization), as well as microbial fertilizers according to the needs of the crops and after a previous control of the soil's fertility; » Application of irrigation and drainage; » Improvement of the chemical properties of the soil, above all the reaction of the soil (calcification of acidic and plastering of alkaline soils); » Elevation of wind protection belts, snow retention and others. The techniques of implementing individual measures to increase and maintain soil fertility at a high level are discussed in other disciplines (subject programs) that are taught at our faculty..

IMPORTANCE AND NEED OF SOIL PROPERTIES RESEARCH

The soil solution reaction is the first basic soil analysis. It is an indicator of the composition of adsorbed ions and indicates the possible need for the application of chemical improvements. At the same time, it is an indicator of the availability and toxicity of nutrients, and the activity of microorganisms in the soil depends on it. Strongly acidic soils show the presence of toxic amounts of Al, Fe, Mn, Zn, Cu and Co, and basic soils show the unavailability or lack of Fe, Mn, Zn, Cu and Co. The reaction of the soil solution strongly reflects the presence of CaCO3, which influences the soil to have a neutral, slightly to moderately alkaline reaction.

Humus, in addition to being a source of nutrients that pass into an available form after its mineralization, also has great importance for the physical and chemical properties of the soil, which are studied during the preparation of the pedological study. Humus is a waterproof adhesive for bonding soil aggregates in a stable granular structure that provides high porosity, a good ratio between capillary and non-capillary pores, a stable porous system, lower values for apparent and direct density, better water permeability and water retention, increasing soil aeration, reduces plasticity, stickiness, cohesiveness and hardness, which positively reflects on the lower consumption of energy to prepare the surfaces for sowing or planting crops. Humus also has a positive effect on the absorption capacity and buffering of the soil.

Knowledge of the mechanical composition (texture) of the soil is of great importance for the physical, physico-mechanical and chemical properties of the soil. The mechanical composition has a particularly great importance for hydrotechnical improvements. Water properties, the ratio between available and unavailable moisture for plants in the soil and the irrigation rate depend on it. During the construction of irrigation systems (lining of canal network, construction of small reservoirs) and drainage (distance between drainage channels), it is necessary to know the mechanical composition of the soil.

The water, air and heat regime of the soil depends on the mechanical composition of the soil. If there is more clay in the soil, with its increase, water retention increases, water permeability and internal drainage decrease, aeration decreases, capillary ascent of water slows down and the soil becomes cooler. Therefore, clay soils are cold, wet and biologically less active, and sandy soils are dry, hot, and suffer from drought. Such regularity occurs when comparing soils with different textures, but under the same other conditions (same mineralogical composition of the clay, same composition of adsorbed ions, same shape of the particles, same structure). In clayey soils, the

influence of the texture is strongly modified by the structure, that is, by the stability of the structural aggregates. The formation of a stable granular structure is the main corrector of poor physical properties in clayey and sandy soils. The physical condition of the soil in conditions of different humidity, apparent density, porosity, water, air and heat regime, the effect of irrigation, etc., depend on the structure. Soils with a stable granular structure show a better effect during irrigation, because they have a higher total porosity and a good ratio between capillary and non-capillary pores. Such soils drain and hold water well, lose less water through evaporation and therefore need to be irrigated less often. Also, soils with a stable granular structure do not change their physical state when humidity changes and have a stable porous system. As a result, water and air in the soil are not antagonists.

The water properties of the soil and the provision of water to the plants depend on the apparent density, that is, on the degree of compactness of the soil. Data from tests on the apparent density of soils indicate that by increasing its values under the same other conditions, water permeability decreases, unavailable moisture expressed as a percentage of the soil volume increases, the capillary movement of water becomes slower and the plant is provided with water only in conditions of higher soil moisture. The knowledge of the apparent density simultaneously allows the calculation of the weight percentages of moisture in volumes, and with them it can further be established how much moisture is available in the soil and how much water in m3 or mm per hectare for a certain surface and depth of the soil should be added with one watering, as well as for calculating the reserves of nutrients and humus in the soil. Together with the knowledge of the value of the direct density of the soil, it allows the calculation of the total porosity of the soil (the amount of capillary and non-capillary pores). This, in turn, has a great significance, among other things, for hydrotechnical improvements. Knowing the capillary porosity shows how much water can be added with one irrigation and how much water the soil can hold without losing it to gravity. Without investigating these parameters, irrigation can easily deteriorate the porosity and structure, thereby increasing the apparent density and decreasing the total and non-capillary porosity of the soil.

1. The study of the water regime of the soil (incomes, expenses and the movement of water in the soil) is of great importance for soil processes, properties, for agricultural crops and for the application of various amelioration and agrotechnical measures.

2. Part of the total porosity of the soil (capillary) represents the water reservoir for normal growth and development of crops. Therefore, the study of field water capacity, permanent wilting moisture and current moisture are necessary parameters for calculating the irrigation rate. It has been established that for each irrigation, as much water is added as the difference between the field water capacity and the current soil moisture. When choosing the method of irrigation, strict care must be taken for infiltration, on which the intensity of irrigation depends. Adding larger amounts of water than the soil can absorb (infiltrate) causes surface water runoff and irrigation erosion. The second point is economic: much more water is consumed than necessary.

METHOD OF WORK

In the Accredited Laboratory for the Analysis of Soils and Fertilizers L-04 of the Department of Soils at the Faculty of Agricultural Sciences and Food in Skopje, the delivered soil samples were prepared (drying, separation of the average/middle sample, crushing and sowing) and the following laboratory analyses:

- hygroscopic moisture by drying the soil samples at a temperature of 105^{0}C to a constant mass;
- The pH of the soil solution in H_2O was determined electrometrically using a glass electrode;
- the content of (carbonates) $CaCO_3$ was determined volumetrically using Scheibler's calcimeter;
- the content of humus is determined according to the spectrophotometric method with the dichromatic method;
- total nitrogen – calculated;
- readily available phosphorus (P_2O_5) according to the Al method;
- readily available phosphorus (K_2O) according to the Al method;
- Determination of the mechanical composition of the soil using 0.1N sodium pyrophosvate;
- Determination of water-physical properties of the soil;
- Determination of soil apparent density Pp g/cm^3
- Determination of soil texture according to the American Triangle. Ion absorption capacity (CEC) cmol(+) kg^{-1}.

Laboratory analyzes of soil properties were performed according to standard methods described by Маркоски, М. Миткова Т. 2015. Митрикески Ј., Миткова Татјана (2001).

INTERPRETATION OF THE RESULTS OF ANALYSIS OF THE SOIL SAMPLES

The interpretation of the obtained results implies their use to determine the required amount and type of fertilizer, their ratio, etc., when fertilizing the soil.

The grouping of the obtained results was carried out for the most important elements of soil fertility, and they are the most requested and used in agrotechnical practice:

- (pH) reaction of the soil solution
- the content of carbonates ($CaCO_3$)
- the humus content
- presence of readily available forms of phosphorus P_2O_5 and
- readily available forms of potassium K_2O
- Absorptive capacity (CEC);
- Mechanical composition soil texture
- Water-physical properties

The reaction of the soil is of great importance for the interpretation of the results obtained from the performed soil analyzes and the control of soil fertility, during the use of fertilizers (especially in the selection and type of fertilizer). The reaction is the main condition for the transformation of the mineral fertilizer in the soil and affects the dynamics of availability of nutrients in the soil.

pH is a unit of measure that expresses the degree of acidity or basicity of the soil. Measurement of the pH value of a soil sample is carried out with a pH meter. Acidification of the soil can also be caused by industrial pollutants, especially acid rain in the wider areas of larger energy factories, but some natural processes can also be the cause. Soil reaction affects plants directly through the toxicity of increased concentrations of H+ and OH- ions or indirectly through the influence of changes in a range of soil properties. The intermediate influence of pH is seen through changes in the availability of biogenic elements or through changes in the activity of microorganisms in the soil. Different plant species do not tolerate the same effects of the acidic reaction of the soil. As opposed to acidity, most plants do not tolerate the increased alkalinity of the soil that is typical of an arid (dry) climate.

Soil classification according to pH value in H_2O

Soil reaction	*pH value in H_2O*
very acidic	***< 4.5***
acidic	***4.51-5.50***
slightly acidic	***5.51-6.50***
neutral	***6.61-7.20***
slightly alkaline	***7.21-8.00***
alkaline	***> 8.01***

The content of carbonates ($CaCO_3$) is important for the application of organic fertilizers and some mineral fertilizers. The presence of calcium carbonate affects the reaction of the soil, in providing optimal conditions for the mineralization of organic matter in the soil and for the correct selection of mineral fertilizers (correct form and presence of active substances, especially in the case of phosphorus fertilizers and trace elements).

According to the content of total CaCO3, the soils can be:

carbonated	*0 %*
slightly carbonated	*0-5 %*
medium carbonate	*5-10 %*
very carbonated	*> 10 %*

Hummus. The content of humus in the soil affects its fertility due to its positive properties. The organic matter in the soil originates from the remains of living organisms, which are more or less decomposed and then rebuild the organic compounds of the soil.

The organic matter in the soil represents:

– a source of nutrients for plants;

– basic actor of the soil structure;

– stability of soil aggregates;

– soil cultivation factor;

– helps in the movement of water and air in the soil;

– helps in water retention;

– prevents erosion;

– has a buffering effect (pesticides, nutrients, etc.);

– prevents the leaching of nutrients from the zone of the root system into the deeper soil layers;

– gives color to the soil (warming).

The amount of organic matter is small compared to the rest of the soil, but it is still essential because:

• determines the difference between soils;

• affects many significant physical and chemical properties of the soil;

• represents a basic source of energy for the life activity of microorganisms living in the soil.

According to the humus content, soils are classified into groups:

Group	*Humus content in %*		
	Sandy	*silt*	*Clay*
High	> 2,5	> 4.00	> 5.0
Middle	1,0 - 2,5	1.5 - 4.0	2.0 - 5.0
Low	1,0	1.5	2.0

Total nitrogen content

Nitrogen occupies a special place in the group of essential elements. It originates from the atmosphere (N_2), but is adopted in mineral form and is therefore included in the group of mineral elements. It is a component of proteins, nucleic acids, photosynthetic pigments, amines, amides and other compounds that form the basis of life, and therefore the chemistry of this element is the most important part of plant nutrition. The importance of nitrogen is even greater in that it can be used by only a small number of organisms from the atmosphere (where it is 78.1%) in the gaseous state (N_2). A huge amount of energy (946 KJ = 226 Cal) is required to convert the molecular form of nitrogen to ammonia and nitrates, in which form plants adopt it. On the other hand, nitrogen easily returns to the molecular state in which it is most stable, so it is easily lost from the soil. Nitrogen in the soil is found in the form of organic and inorganic compounds. Inorganic nitrogen N comes in the form of nitrates (NO_3^-) and ammonium compounds (NH_4^+). Nitrogen in the soil is mostly found at a depth of 0-20 cm, in insignificant amounts, namely: 3-8 ppm NH_4 and 3-10 ppm NO_3. The largest amounts of nitrogen amount to 3000-4000 kg/ha and are mainly bound in the organic matter. However, some soil nitrogen is fixed in the form of ammonium ions in clay minerals and organic matter.

The organic part of nitrogen is represented by humus and incompletely decomposed plant and animal remains.

The content of nitrogen in the soil depends primarily on the amount of humus, which contains an average of 5%, and in dry areas up to 10% of nitrogen.

Nitrogen in the soil is found in these forms:

- In the form of ammonium or nitrate compounds, but only 1-2% of the total nitrogen;
- In organic compounds, which are easily decomposed, giving substances capable of nitrification (amino acids and amides);
- In organic compounds that are slowly decomposed by soil microorganisms.

Easily available phosphorus P_2O_5. The grouping of soils according to the content of readily available phosphorus is of great importance for the application of mineral fertilizers. According to the Al method, the grouping of soils based on availability of readily available phosphorus is carried out in the following way:

Security	***Content of P_2O_5 /mg/100g***	
	pH > 6	***pH < 6***
low secured	< 8	< 5
poor	8 - 10	6 -10
medium	10 - 20	10 -16
rich	20 - 35	16 - 30
very rich	> 35	> 30

The determination of readily available phosphorus in the soil is aimed at determining the provision of the soil with this essential element for plant nutrition, and on that basis, the required amount of phosphorus fertilizers is determined.

Phosphorus is a non-metal that occurs in nature, soil and plants in pentavalent form. It is part of important organic compounds such as nucleoproteins, phospholipids, enzymes and many others. The phosphorus cycle consists of the breakdown of phosphorus compounds in the soil, their uptake by plants, and the regeneration of soil minerals. As many as 170 minerals containing phosphorus are known, and they are scattered throughout all igneous rocks.

Phosphorus in the soil comes as organic and mineral phosphorus. The content of organic phosphorus depends on the organic matter in the soil. About 50% of organic phosphorus is in the form of phytins, nucleic acids (DNA and RNA) and lecithin. Phytin comes from the seeds of plants, and some of it is created through microbial processes in the soil. Compounds of phytin with Ca, Mg and Al are hardly soluble. Organic phosphorus enters the soil through barnyard and green manure, compost, forest litter, root debris, and dead soil-dwelling microorganisms, insects, and animals. This phosphorus becomes accessible to plants after decomposition, that is, after the mineralization of organic substances.

Changes in phosphorus compounds in the soil occur under the biological influence of plants and microorganisms and colloidal-chemical processes. The direction and character of these processes depends on the reaction of the environment (pH), the content of carbonates and other factors.

Plants also play a role in the mobilization of phosphorus compounds in the soil. Some crops make good use of hard-to-dissolve phosphates - phosphorite and apatite, because they acidify the soil solution quite a bit with their roots, secreting a lot of H - ions, i.e. various acids. These include lupine, buckwheat, peas, while cereal crops use these hard-to-dissolve phosphates much more difficult.

Phosphorus fertilizers are better used when they are introduced locally into the zone of the root system (in rows) than when they are scattered over the entire surface, because the root receives phosphorus only from the soil with which it is in direct contact with it. Microorganisms that secrete organic acids play the biggest role in the breakdown of mineral phosphates. These processes in the soil are also affected by mineral acids that occur during various microbiological processes, as well as from the application of various physiologically acidic manures (KCl, (NH4)2SO4). Organic phosphorus is also broken down by microbial processes. The transformation of phosphorus from humus is more difficult and the same phosphorus is less available to plants, while that from stable and green waste and from organic plant residues decomposes faster.

Easily available potassium K2O. When grouping the soil according to the content of readily available potassium (Al method), the mechanical composition of the soil and the content of humus are taken into account, due to the interdependence of these two parameters.

Security	Content of K_2O /mg/100g		
	Sandy	**silt**	**Clay**
low secured	< 10	< 8	< 5
poor	10 -15	8 -12	5 - 8
medium	15 - 24	12 - 20	8 -12
rich	24 - 40	20 - 35	12 - 20
very rich	> 40	> 35	> 20

The determination of readily available potassium in the soil aims to determine the provision of the soil with this essential element for plant nutrition. The amount of potassium fertilizers required will be determined based on its presence in the soil.

Potassium is an alkali metal that is very widespread in nature. In the soil and in plants, it is found only as a monovalent cation (K+) with reducing properties. It is not included in the composition of organic substances, but is loosely bound mostly to proteins. Potassium has the role of a specific activator, that is, a modulator of enzyme activity.

The potassium in the soil originates from the rocks and minerals, which provided the material for its formation. Some of the potassium from rocks and minerals remains in the soil in a poorly soluble form, and only to a lesser extent is in a form available to plants.

Potassium in the crystal lattice of minerals constitutes the main reserve of potassium in the soil. During the decomposition of minerals under the influence of various factors, potassium becomes available to plants. Such decomposition is carried out under the influence of acids, water, temperatures and certain bacteria.

Exchangeable potassium is bound to the surface of organic colloids and clay particles. Exchangeable potassium accounts for less than 1/100 parts of total potassium, but directly or indirectly, is an important source of potassium for plant nutrition.

Potassium in the soil solution or soluble potassium is found in the form of potassium ions (K^+). Soluble potassium is directly accessible to plants, but those amounts are not sufficient for high yields. In organic matter (humus) there is less than 0.1% readily available potassium (K_2O). Harvested organic residues contain certain amounts of K: cereals 9 – 15 kg/ha, trench crops 30 – 48 kg/ha, alfalfa 64 kg/ha, clover 75 kg/ha. For example, plowing in cut corn stalks, leaf and sugar beet heads returns significant amounts of potassium and reduces the need for potassium fertilizers.

RESULTS OF SOIL COMPOSITION

The analyzed soil profiles are presented tabularly. From the results of the analyzed representative profile, a great heterogeneity of the mechanical composition can be seen. The excavated soil profiles are located in K.P. 3149/1 in **Municipality Kriva Palanka.**

Table no. 2. Mechanical composition of the soil in K.P. 3149/1 IN Municipality Kriva Palanka

No	Dept. cm	Coarse sand	Fine sand	Total sand	Cley	Silt	Cley + silt
K.P. 3149/1 IN M. Kriva Palanka							
1.	0-30	11,71	23,49	35,2	36,4	28,4	64,8
1.	30-60	7,23	23,77	31,0	29,0	40,0	69,0
2.	0-30	6,87	28,83	35,7	33,0	31,3	64,3
2.	30-60	7,81	26,99	34,8	20,7	44,5	65,2
3.	0-30	10,73	25,87	36,6	48,5	14,9	63,4
3.	30-60	3,25	16,85	20,1	19,0	60,9	79,9
4.	0-30	9,55	15,75	25,3	57,2	17,5	74,7
4.	30-60	7,14	21,76	28,9	12,8	58,3	71,1
5.	0-30	26,47	26,83	53,3	35,70	11,0	46,70
5.	30-60	15,23	36,87	52,1	34,90	13,0	47,90

This table shows the textural composition of the investigated soil samples by profiles and the volume density of the soil.

Табела 3. Водно физички својства на почвата

	Dept. [cm]	texture	*Pp* [g/cm³]	T.V %	PVK %	MKV %	FAW %
K.P. 3149/1 IN M. Kriva Palanka							
1.	0-30	silt	1.31	20,19	33,20	50.56	13.01
1.	30-60	silt	1.34	16,30	30,83	49.61	14.52
2.	0-30	silt	1.33	18,40	31,64	49.98	13.24
2.	30-60	silt	1.39	12,68	27,31	47.46	14.62
3.	0-30	silt	1.27	26,75	38,28	52.05	11.52
3.	30-60	silt cley	1.38	11,81	29,19	48.05	17.37
4.	0-30	send cley silt	1.22	32,64	45,22	53.78	12.57
4.	30-60	send cley	1.45	10,10	26,97	45.23	16.87
5.	0-30	send cley	1.35	19,80	29.55	49.14	9.75

5.	30-60	send cley	1.35	19,42	29.45	49.10	10.03

TV-Withering point; PVC - water capacity; MKV- maximum capacity for water and FAV-Physiologically active water.

The mechanical composition or texture of the soil depends on the substrate from which the soil is formed and on the processes that take place in it during pedogenesis and evolution. The soil from the substrate receives particles of the most different dimensions: from the smallest, colloidal to the largest, stony, and that is why it is called a polydisperse system. Each individual particle in the solid phase of the soil is referred to as a primary particle or mechanical (granulometric) element, in contrast to the secondary elements which are called structural aggregates. The mechanical elements represent elementary (primary) soil particles of different sizes which, under the influence of weak forces (under the pressure of the fingers or a weak jet of water), do not divide or destroy. When determining the mechanical composition of the soil, it is impossible to measure

the dimension of each particle separately and therefore they are grouped (fractionated) into groups, i.e. fractions, whereby the amount of different fractions in the soil is determined by the mechanical analysis. The term fraction means a group of mechanical elements with a certain dimension, and mechanical analysis means the determination of the content of the different fractions in the soil. In the laboratory, when a mechanical analysis of the soil is done, it is previously sieved through a sieve with openings of 2 mm, and organic substances are removed. After completing the analysis, the separate fractions of mechanical elements expressed in % are obtained (for example, 30% sand, 35% dust and 35% clay). In this way, the mechanical composition of the soil is determined. The mechanical composition or texture of the soil means the content of various fractions of mechanical elements expressed in weight, i.e. mass percentages. In different countries of the world there are different classifications of mechanical elements. In our country, the classification of the International Union of Soil Sciences (IUSS – The International Union of Soil Sciences) is accepted, according to which the mechanical elements are divided into two groups with several fractions.

Each fraction of the group of gravel and fine soil has its own characteristics. The skeleton (stones and gravel) is obtained by physical decomposition. It consists of pieces of undisintegrated rock with a rounded shape (if transported over a longer distance) or with sharp edges if the soil was formed in situ ("in situ"), or transported over a short distance. According to the mineralogical composition, it can be carbonate, silicate, quartz and mixed. This fraction is more represented in mountain soils, and it is also found in agricultural soils formed on coarser alluvial, deluvial or lake sediments. The small presence of gravel and stones improves the growth and development of agricultural crops on clay soils. But if their presence is greater than 20%, then there is a negative impact on the cultivation of agricultural crops. Such surfaces are cleaned of large stones and gravel so as not to damage the mechanization during soil cultivation. Soils rich in skeleton retain water poorly, heat up more strongly in summer, are washed more strongly and are poor in nutrients. The sand fraction is obtained by physical decomposition. It is very permeable, does not retain water, in its dry state it is unbound and the grains cannot come together, and it does not raise water at all or very little by capillary action, it is not plastic and it is not sticky.

It occurs in all soils in a greater or lesser percentage (from 5 to 10 %, even over 95 %), and the most favorable content in the soil is 40 to 70 %. In clay soils, it reduces the negative properties of clay. By mineralogical composition, sand can be quartz, carbonate, silicate and

mixed. Quartz sand consists of SiO_2, is infertile, plays only a mechanical role and constitutes the skeleton of the soil. Silicate consists of silicate and aluminosilicate minerals, it decomposes slowly and can yield some clay and various salts, including nutrients. That is why it is marked as "potentially" fertile. Sand-rich soils are dry, warm, highly permeable and poorly water-retaining, and poor in nutrients. The dust fraction, according to its properties, makes a transition between sand and clay. It is mostly obtained by physical decomposition. It holds it better, but lets the water through less than the sand. The powder is characterized by a high capillary absorption of water, does not or very poorly settles, is weakly sticky and weakly plastic. In the dry state it is hard (bound) and has the appearance of flour. The highest percentage of dust is found in soils formed on loess and dusty alluvial deposits. According to mineralogical composition, it mostly contains quartz and opal, less mica, and maybe calcite and dolomite. Clay is formed by chemical decomposition. It barely lets water through, but it retains it well, and it slowly raises the water by capillary action. In a wet state, it is plastic and sticky, and in a dry state it contracts, cracks and hardens strongly. Compared to other fractions, it retains the most water and nutrients. This is due to the small size of the particles and the permanent electrified charge. Different soils differ in terms of the content and percentage of sand, dust and clay fractions. In that context, several textural classes of soils are distinguished.

All classes are usually grouped into three basic groups, so sandy, loamy and clayey soils are distinguished. Sandy soils are well aerated, have good water permeability, but low water retention, are easily heated and are therefore labeled as "dry and hot" soils. They are characterized by low plasticity, stickiness and cohesion. They are easy to process, have a low content of clay and humus, low absorption capacity, i.e. retain very little nutrients in them. Clean sands can be used in forestry, and sandy soils with more clay can also be used in agriculture. Their fertility is increased by increasing the content of clay and humus, and by applying artificial fertilizers that should be added more often and in small doses to avoid the risk of leaching and environmental pollution. Clay soils have completely opposite properties compared to sandy soils. They are characterized by poor physical and relatively good chemical properties. They have high water retention, but low water permeability and aeration. They are more difficult to heat and therefore are often labeled as "wet and cold" soils. They are characterized by high plasticity, stickiness and swelling in the wet state and hardness, compactness and cracking in the dry state. Soils with a high content of clay (especially from the group of smectites, montmorillonite) are designated as

"heavy" soils. They have a relatively short interval of high-quality tillage and at the same time provide strong resistance. As a result of the unfavorable water, air and heat regime, they have reduced biological activity. Also, these soils are problematic, both during irrigation and drainage. Due to the high content of clay and better humus, they have a high absorption capacity, and are distinguished by a higher buffering capacity. They can be fertilized less often, but with higher doses of phosphorus and potassium fertilizers, without the risk of washing them away.

Loamy soils constitute the transition between sandy and clayey soils. They have good physical and chemical properties. They contain approximately equal amounts of sand, dust and clay. They pass and retain water well and are well aerated. When they have a favorable humidity, they give good processing quality and are therefore labeled as "medium heavy" soils. They have a good absorption capacity, contain and retain nutrients well, and can be fertilized with high doses of fertilizers without the risk of them being washed away.

Significance of mechanical composition for other soil properties for agricultural production

According to what has been said so far, the texture of the soil is of great importance for the genesis and evolution of the soil, for the physical, physico-mechanical and absorptive properties of the soil, and it has immediate importance for the agricultural production. In nature, the mechanical composition is one of the most stable soil characteristics. The water, air and heat regime of the soil depends on the mechanical composition. On the one hand, the water-air regime also depends on the mineralogical composition of the clay. A soil with 40% montmorillonite type clay has much worse physical properties than a soil containing 70% kaolinite. On the other hand, two clay soils, with the same percentage of clay and other fractions, may have different water, air and heat conditions if they have different structures. Structureless clay soils have poor, and clay soils with a stable grain structure have good physical properties. The physical properties of soils with the same clay content are better if there are more adsorbed Ca2+-ions in the soil adsorptive complex than H+ and Na+-ions. Also, with the same percentage of clay, if in one soil the mechanical elements have a plate and disk shape, the stickiness, plasticity and cohesion are more pronounced, compared to the other one that has spherical mechanical elements. Some authors consider that the mechanical composition represents one of the morphological properties of the soil. In the field, by digging the soil profile and during its morphological description, the mechanical composition of

the soil can be qualitatively determined by feeling and crushing the dry soil and by rolling and crushing the wet soil under the fingers. In this way, at least 5 textural classes can be determined: sandy, sandy-loamy, loamy, loamy-loamy and clayey. The choice of cultural plants for sowing and planting depends very much on the mechanical composition of the soil. So, on soils with a lighter mechanical composition, it is better to grow root and tuber crops, tobacco, potatoes and early garden crops. The application of various ameliorative and hydrotechnical measures are also closely correlated with the mechanical composition. Soils with a lighter mechanical composition need to be irrigated more often in smaller quantities, unlike "heavier" soils. This is also related to the placement of the irrigation and drainage systems (the distance of the channels, drains, etc.), as well as to the choice of the irrigation method (artificial rain, drip irrigation, surface irrigation, etc.). The processing interval for soils with a lighter mechanical composition is longer, and for clay soils it is very short. The higher content of clay in the soil causes greater resistance during processing, thus increasing the costs of this operation. Processing, especially deep processing, can change the mechanical composition when mixing two layers or horizons with different mechanical composition. The mechanical composition can be modified by cleaning the skeleton from the soil, by leveling the soil for irrigation, etc. Chemical meliorations, i.e. the amount of lime (CaCO3) for calcification of acidic soils and of gypsum (CaSO4) for plastering of salty soils is greater if the soil contains more clay. The choice and doses of mineral fertilizers depend on the mechanical composition of the soil. In "lighter" soils, nutrients are washed away more and therefore more frequent fertilization with lower doses is required. Eutrification of groundwater is higher in these soils. With clay soils, there is no danger of nutrients being washed away, and therefore they can be fertilized less often and in larger doses. The mechanical composition is also important for the erodibility of the soil. Other things being equal, soils richer in dust and non-structural are more strongly eroded. The textural differentiation of the soil (the profile) is also of great importance for agricultural production. Strong textural differentiation (differences in mechanical composition between horizons) is detrimental. Plants require as homogeneous an environment as possible for their growth and development. Therefore, the farmer tends to create a homogeneous and deep arable layer. Finally, if it is economically justified, man can change the mechanical composition of the soil in the direction of improving its properties by adding sand to clay soils, that is, clay to sandy soils. This experience proved to be very positive in Germany, by covering sandy soils with a loess layer of 20 cm (2 000 m3 /ha loess).

Table No. 5 CHEMICAL PROPERTIES OF THE SOIL FOR K.P. 3149/1 IN Municipality Kriva PALANKA

No	Dept. cm	Organic mater [%]	Total Nitrogen N [%]	pH in H_2O	$CaCO_3$ [%]	P_2O_5 [mg/100 g soil]	K_2O [mg/100 g soil]	CEC cmol$^{(+)}$ kg^{-1}
K.P. 3149/1 IN M. Kriva PALANKA								
1.	0-30	1,89	0,112	6,39	0,0		8,85	19.68
1.	30-60	1,10	0,102	6,83	0,0	2,92	7,81	17.22
2.	0-30	1,42	0,117	7,90	12,90	3,50	9,21	18.3
2.	30-60	1,10	0,076	7,96	13,06	2,93	7,49	14.21

3.	0-30	2,06	0,112	7,07	0,00	3,89	7,17	23.46
3.	30-60	1,28	0,103	7,13	0,00	2,90	6,65	14.15
4.	0-30	1,86	0,068	7,93	12,49	7,38	11,09	26.77
4.	30-60	0,90	0,036	8,12	15,82	4,54	8,73	11.77
5.	0-30	1,87	0,124	6,30	0,00	3,78	20,03	18.59
5.	30-60	1,12	0,104	6,10	0,00	3,53	24,03	18.36

INTERPRETATION OF RESULTS OBTAINED BY PEDOLOGY ANALYSIS

Based on the obtained results for the mechanical composition, a great heterogeneity can be observed in terms of profiles and depth, so they are described as loamy and loamy, sandy loamy loamy.

They are characterized by a high content of total sand, while the representation of clay is quite variable in profiles and depths. The high sand content makes them quite water permeable.

Regarding the pH reaction, which is a limiting factor in agricultural production, in the studied profiles it has quite uniform values by profile and depth.

Table 7. Values for pH in aqueous solution

mark	dept cm	K.P. 3149/1 IN M. Kriva PALANKA	classification
		pH in H_2O	
1.	0-30	6.39	Moderately acidic
1.	30-60	6.83	neutral
2.	0-30	7.9	Moderately alkaline
2.	30-60	7.96	Moderately alkaline
3.	0-30	7.07	neutral
3.	30-60	7.13	neutral
4.	0-30	7.93	Moderately alkaline
4.	30-60	8.12	alkaline
5.	0-30	6.3	Moderately acidic
5.	30-60	6.1	Moderately acidic
1-5	0-60	7.17	neutral

The reaction of the soil solution is strongly influenced by the content of $CaCO_3$. The soil samples are non-carbonate along the entire depth of 2 soil profiles.

Table 8. Carbonate content, (%)

mark		K.P. 3149/1 IN M. Kriva	

	dept cm	PALANKA	classification
		CaCO3 IN %	
1.	0-30	0	No carbonates
1.	30-60	0	No carbonates
2.	0-30	12.9	carbonates
2.	30-60	13.06	carbonates
3.	0-30	0	No carbonates
3.	30-60	0	No carbonates
4.	0-30	12.49	carbonates
4.	30-60	15.82	carbonates
5.	0-30	0	No carbonates
5.	30-60	0	No carbonates
1-5	0-90	**5.43**	**moderately carbonated**

The humus content of the soil is significant as a source of nutrients. It is a waterproof adhesive for bonding soil aggregates, improves the porosity and capillarity of the soil, the apparent and direct density, water permeability and water retention of the same. And according to the values for this parameter there is a big difference in relation to the depth of the soil.

Table 9. Content of humus, (%)

mark	dept cm	K.P. 3149/1 IN M. Kriva PALANKA	classification
		Humus in %	
1.	0-30	1.89	Low humus
1.	30-60	1.1	Low humus
2.	0-30	1.42	Low humus
2.	30-60	1.1	Low humus
3.	0-30	2.06	Low humus
3.	30-60	1.28	Low humus
4.	0-30	1.86	Low humus
4.	30-60	0.9	Low humus
5.	0-30	1.87	Low humus
5.	30-60	1.12	Low humus
1-5	**0-90**	**1.46**	**Low humus**

Nitrogen (N) is a macro element that is an integral part of proteins, nucleic acids, photosynthetic pigments, amines, amides and other compounds. The organic part of nitrogen is represented by humus and incompletely decomposed plant and animal remains. The nitrogen content in the soil depends primarily on the amount of humus. The nitrogen content of the soil decreases as you go to the deeper soil layers. These values indicate that larger amounts of organic fertilizers or other organic matter should be added to the soil, and it should also be noted that plowing these surfaces is a mandatory measure to mix the soil layers. Fertilization with nitrogenous mineral fertilizers should be carried out continuously during the cultivation of agricultural crops.

Table 10. Total nitrogen content, (%)

mark	dept cm	K.P. 3149/1 IN M. Kriva PALANKA Total Nitrogen (N) in %	classification
1.	0-30	0.112	poorly secured
1.	30-60	0.102	poorly secured
2.	0-30	0.117	poorly secured
2.	30-60	0.076	poorly secured
3.	0-30	0.112	poorly secured
3.	30-60	0.103	poorly secured
4.	0-30	0.068	poorly secured
4.	30-60	0.036	poorly secured
5.	0-30	0.124	poorly secured
5.	30-60	0.104	poorly secured
1-5	**0-90**	**0.095**	**poorly secured**

Phosphorus (P2O5) is an element that is part of important organic compounds such as nucleoproteins, phospholipids, enzymes and many others. It is found in the soil as organic and mineral phosphorus. The phosphorus cycle consists of the breakdown of phosphorus compounds, their uptake by plants and the re-degradation of minerals through the mineralization of plant residues. Because of this data, it is recommended to add larger amounts of fossorial fertilizers before the rooting itself.

Table 11. Phosphorus content, (mg/100 g soil)

mark	dept cm	K.P. 3149/1 IN M. Kriva PALANKA P_2O_5, [mg/100 g soil]	classification
1.	0-30	3.31	Very low secured
1.	30-60	2.92	Very low secured
2.	0-30	3.5	Very low secured

2.	30-60	2.93	Very low secured
3.	0-30	3.89	Very low secured
3.	30-60	2.9	Very low secured
4.	0-30	7.38	Very low secured
4.	30-60	4.54	Very low secured
5.	0-30	3.78	Very low secured
5.	30-60	3.53	Very low secured
1-5	**0-90**	**3.86**	**Very low secured**

Potassium (K_2O) is an alkaline element that is quite widespread in nature. In the soil and in plants, it is found only as a monovalent cation (K^+) with reducing properties. It is not included in the composition of organic substances, but is loosely bound mostly to proteins. Potassium has the role of a specific activator, that is, a modulator of enzyme activity.

Potassium in soil comes from rocks and minerals. Some of the potassium from rocks and minerals remains in the soil in a poorly soluble form, and only to a lesser extent is in a form available to plants. Since the soils are sandy, slightly sandy, according to the obtained results for this element, most of the soils, that is, the plots, are in the poor class.

Therefore, for this macro element before the weeding is carried out, it is recommended that potassium be included with the meliorative fertilization.

Table 12. Potassium content, (mg/100 g soil)

mark	dept cm	K.P. 3149/1 IN M. Kriva PALANKA K_2O [mg/100 g soil]	classification
1.	0-30	8.85	low secured
1.	30-60	7.81	low secured
2.	0-30	9.21	low secured
2.	30-60	7.49	low secured
3.	0-30	7.17	low secured
3.	30-60	6.65	low secured
4.	0-30	11.09	low secured
4.	30-60	8.73	low secured
5.	0-30	20.03	Medium secured
5.	30-60	24.03	Medium secured
1-5	**0-90**	**11.11**	**low secured**

Knowing the absorptive capacity of the soil is of great importance. Many physical and chemical properties of the soil depend on it, as well as its fertility. Thanks to the retention forces, the washing (eluviation) of many substances, including nutrients, which are necessary for plant nutrition, is impossible or difficult in the soil. Closely related to adsorption are fertilization, as well as the application of other chemical-ameliorative and agrotechnical measures. Therefore, adsorption is counted among the most important properties not only of colloids, but also of the soil as a whole. Soils have a different adsorption capacity that depends on the content of organic matter, the mechanical composition and the composition of clay minerals, as well as on the reaction of the solution that displaces the adsorbed ions during their determination..

Table 13. Content of the absorptive capacity (CEC)

mark	Dept cm	K.P. 3149/1 IN M. Kriva PALANKA CEC [cmol(+) kg^{-1}]	classification
1.	0-30	19.68	Medium CEC
1.	30-60	17.22	Medium CEC
2.	0-30	18.3	Medium CEC
2.	30-60	14.21	Medium CEC
3.	0-30	23.46	Medium CEC
3.	30-60	14.15	Medium CEC
4.	0-30	26.77	Medium CEC
4.	30-60	11.77	Medium CEC
5.	0-30	18.59	Medium CEC
5.	30-60	18.36	Medium CEC
1-5	**0-90**	**18.25**	**Medium CEC**

Table 14. water capacity PVK in

mark	Dept cm	K.P. 3149/1 IN M. Kriva PALANKA PVK [%]	classification
1.	0-30	33.2	Medium
1.	30-60	30.83	Medium
2.	0-30	31.64	Medium
2.	30-60	27.31	Medium
3.	0-30	38.28	Medium
3.	30-60	29.19	Medium
4.	0-30	45.22	Medium
4.	30-60	26.97	Medium
5.	0-30	29.55	Medium

5.	30-60	29.45	Medium
1-5	**0-90**	**32.16**	**Medium**

Table 15. Maximum water capacity MVK in %

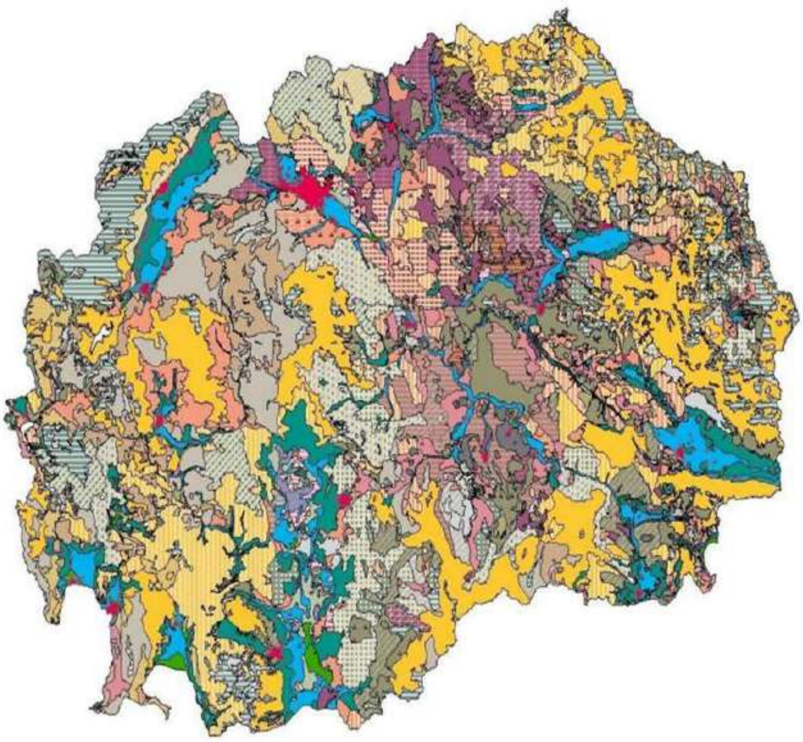
mark	dept cm	K.P. 3149/1 IN M. Kriva PALANKA MVK [%]	classification
1.	0-30	50.56	Medium
1.	30-60	49.61	Medium
2.	0-30	49.98	Medium
2.	30-60	47.46	Medium
3.	0-30	52.05	Medium
3.	30-60	48.05	Medium
4.	0-30	53.78	Medium
4.	30-60	45.23	Medium
5.	0-30	49.14	Medium
5.	30-60	49.1	Medium
1-5	**0-90**	**49.50**	**Medium**

Based on the soil-climatic conditions of the investigated area, the following plant species are recommended (given in a table).

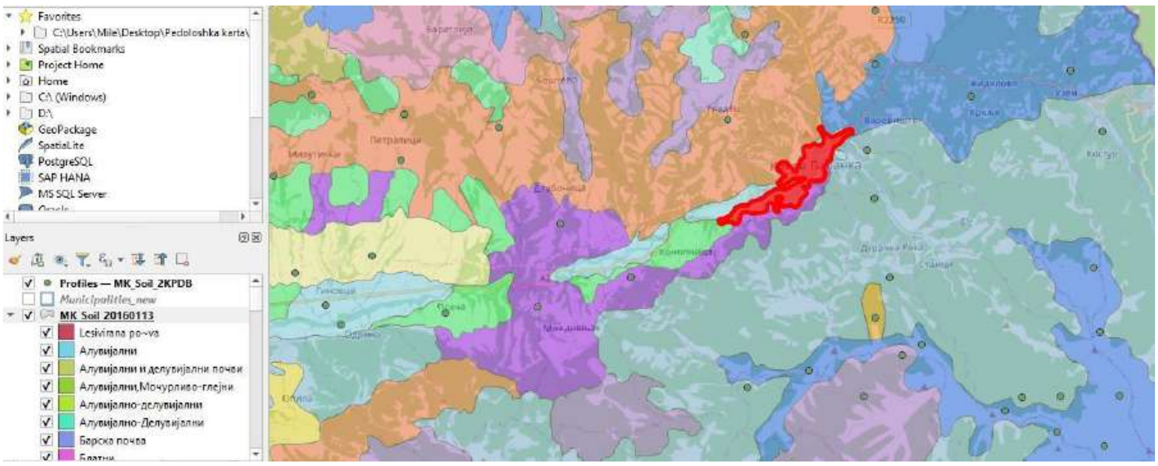
No	Plant Species
1	*Pinus nigra*
2	*Cotoneaster dammeri - bella*
3	*Acer palmatum atropurpureum*
4	*Cotoneaster dammeri - bella*
5	*Salix babylonica*
6	*Alnus spp.*
7	*Prunus laurocerasus otto luyken*
8	*Platanus SPP - Platanus × acerifolia*
9	*Hedera Helix*
10	*Cotoneaster dammeri - bella*
11	*Picea Pungens Glauca*
12	*Fagus atropurpurea*

13	*Fagus moesiaca*
14	*Vinca minor*
15	*Salix babylonica*

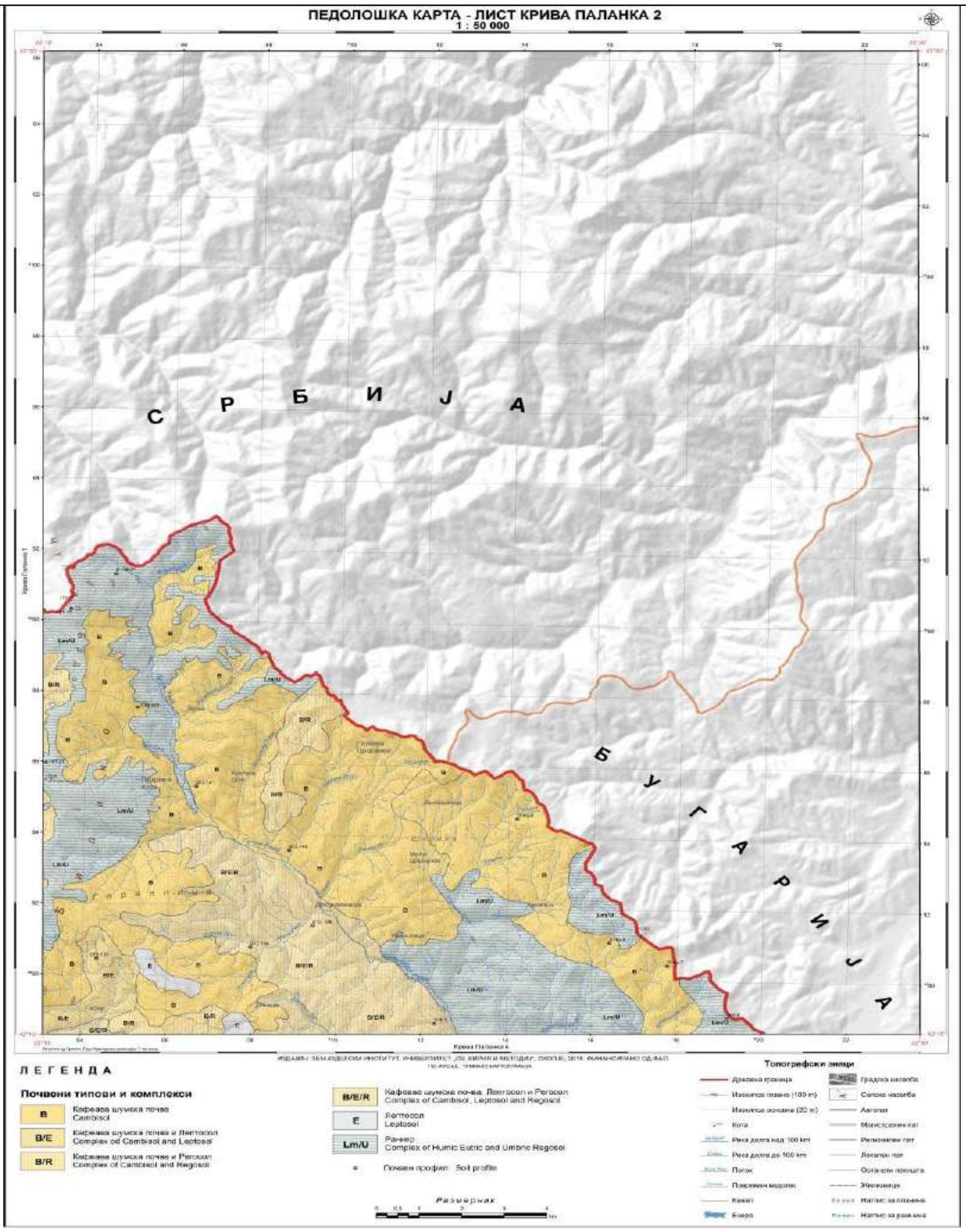
PEDOLOGY MAP OF THE RESEARCH AREA IN SCALE 1: 200 000



Soil map of the Republic of North Macedonia



PEDOLOGY MAP OF THE RESEARCH AREA IN SCALE 1: 50 000



Attachment Photos


JCB

INSTITUTE OF SOIL SCIENCE, AGROTECHNOLOGIES AND PLANT PROTECTION "NIKOLA POUSHKAROV"

PEDOLOGY REPORT FOR CONTROL OF SOIL FERTILITY FOR DUPNITSA (BULGARIA)

PARKS 01-01

Interreg (VI-A) IPA Bulgaria - North Macedonia 2021-2027 Programme Priority 1 Greener Border Region (ref. No 2021TC16IPCB006 – 2023-3)

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INTRODUCTION

During the historical development of pedology, a large number of definitions for soil have been given, depending on the aspect from which the soil is viewed. Thus, definitions are found, the foundations of which are more physiological, geological or agricultural-forestry in nature. In some, the morphological or genetic principle is taken, and in others, the soil is seen according to the way of use. Farmers and foresters are the ones who have given the oldest definition of soil. According to them, soil is that part of the earth's crust in which the root system of plants develops. For geologists, soil represents the surface part of the geological layer. One of the first definitions according to which soil is also seen as an environment in which the root system of plants develops was given by Kossovich in 1886. According to him, soil is the surface part of the Earth's crust in which the main root mass of plants develops.

The definition of soil given by the Russian pedologist V. C. Dokuchaev in 1886 is based on the genetic principle and according to him, the soil represents a special natural- historical body, i.e. the surface layer of the Earth's crust, naturally modified by the combined influence of water, air and various types of living and dead organisms.

From an agricultural point of view, the definition given by Janekovic in 1952 is interesting, according to which soil is a loose surface layer of the Earth's crust, a living space for plant roots and is a means of agricultural production.

In practice, it often happens that the word or term "soil" is equated with the word or term "land". In our country and in some other countries with the same meaning, the words or terms "soil" and "land" are used as synonyms.

The term "land" denotes a terrestrial bio-productive composition that includes, in addition to the soil, climate, relief, geological substrate, vegetation and other living communities, as well as the ecological and hydrological processes that take place in that composition.

From the two definitions, it can be said that the term "land" has a broader meaning and applies to other users outside of agricultural production. The land can be defined according to the function and method of use as agricultural, forestry, construction, etc., according to the state and private ownership. Besides among these, there is also the word "Earth" which refers to our planet, as well as to the State (Bulgaria).

Functions and basic characteristics of the soil

Soil has numerous ecological functions that are essential for the environment, but also for the economy and progress of society as a whole. As a dynamic polydisperse system with many functions, soil provides support for the entire ecosystem.

③ The most important function of the soil is the production of biomass (food).

② Soil is part of the large (geological) and small (biological) circular movement of

matter and energy in nature and plays a significant role in it..

④ Soil also plays a significant role in the hydrological cycle (the movement of water) in nature. The soil receives, retains, conducts and releases water. Part of the water

that is retained is significant for the water supply of the plants.

The soil is a home and habitat in which a large number of representatives of the

① micro and macro fauna live and act. It is a genetic reservoir (a quarter of global biodiversity), much larger than water and air.

④ Soil is a reservoir (guardian) of organic carbon and has a major role in climate

change.

The soil is a purifier (recycler) of the environment. It retains and transforms many

② harmful substances that come from other components of the environment (water, air...) and are mostly a product of human activities.

⑤ The soil is a platform for the construction of various objects.

⑥ The soil is a geological and cultural heritage, a part of the landscape, and it holds many archaeological artifacts and paleontological materials, which speak about the

history of man and the evolution of the living world.

- The soil changes the atmosphere. In places where the soil is dry, without vegetation and with a destroyed structure under the influence of the wind, the lifting of soil particles (dust, sand...) and their increased presence in the air, the atmosphere can occur. This can reduce visibility and pose a health hazard to people as a result of breathing dirty air. Conversely, moist and structured soils can prevent such dust-enriched air. Evaporation of moisture from the soil is a source of water vapor in the atmosphere, thus causing changes in air temperature. By "breathing" the soil, the composition of the individual gases between the soil and the atmosphere also changes, with some of them affecting the global warming of the Earth and climate change.

The soil is a special sphere in which the paths of the living and the dead world meet and intertwine, creating a new sphere called the pedosphere.

Soils differ from each other, but they all have common characteristics, namely:

- The soil is a three-phase system, consisting of a solid, liquid and gaseous phase.

The solid phase occupies approximately 50% of the total volume of the soil mass and consists of mineral and organic part, and the remaining 50% belongs to the liquid phase (water and dissolved substances in it - soil solution) and gaseous phase (soil air). Therefore, the main four components are: mineral and organic matter (in the solid phase), water and air. Soil is triphasic because it is porous, full of tiny, interconnected voids or pores. It is considered optimal for most plants when the ratio of the components in the separate phases of the soil expressed in volume percentages is as follows: for mineral substances about 45%, for organic substances about 5% and for air and water about 20 to 30% each. This ratio indicates that pores occupy about 50% of the soil volume. It is not empty space. It is the living space of the entire living world in the soil, water and air move through that space and many intensive processes take place in it.

Soil is a product of the environment. Its formation (pedogenesis) and further changes in it (evolution) are closely correlated with environmental conditions, that is, they depend on soil-forming (pedogenetic) factors: parent substrate (parent material), relief, climate, organisms and time. In nature, soil is not an isolated system. It is an integral and very significant part of the ecosystem, which represents a complex of living organisms (plants and animals) and their immediate environment (soil and atmosphere). As part of the ecosystem, the soil is an open system, which means that between it and the other spheres (atmosphere, hydrosphere, biosphere and lithosphere) there is a constant exchange of substances and energies with the pedogenetic processes through which the soil is formed and constantly changes.

The soil has its own appearance, its own morphology. However, one of the most important characteristics of the soil is the anisotropy in the vertical sense, that is, the successive (simultaneous) appearance of horizons in depth that differ from each other in terms of morphological, physical, chemical, etc. characteristics (properties), figure 5. Anisotropy is a consequence of the action of pedogenetic processes on the parent substrate and evolution. Natural pedogenetic processes are grouped into three groups:

- Decomposition of walls and minerals and formation of new minerals

- Synthesis (creation) and decomposition (decomposition) of organic matter and formation of humus and

- Migration (movement) of substances.

With these processes, the soil changes and acquires its structure, appearance, that is, its morphology, which is not possible to learn if the soil is observed only from the surface. Therefore, it is necessary to dig a hole (profile) at a depth at which the appearance of individual horizons or layers can be observed.

In agricultural soils, as a result of human influence, major changes occur and new anthropogenic soils are created. All human-caused changes are labeled as anthropogenization, which comprises the fourth group of processes.

Soil as a dynamic and evolutionary system. In the soil, physical, chemical, physico-chemical and biochemical processes take place continuously, so that the soil resembles living organisms. Soil is "born" and created from the parent material (parent substrate), developing over time it changes, acquires new properties, evolves from one soil type to another and unfortunately can "die" through various degradation processes (natural and mostly anthropogenic).

Changes in the soil cause changes in other components of the ecosystem as a result of their connection.

The soil as a three-dimensional body between the lithosphere and the atmosphere. In nature, each type of soil occupies a certain space, has a horizontal extension (width), length and depth. Unlike the upper limit, which is sharply defined in relation to the atmosphere, the lower limit is not, because the soil usually gradually passes into the lithosphere.

Soil as an environment for cultural and other plants. For normal development, plants need certain conditions and factors. Of all the factors needed to obtain high and stable yields, except for the light factor, all the rest are provided by the soil: it contains the root system of cultivated plants (mechanical support) from where they are constantly provided with water, nutrients, oxygen and heat . Hence the great importance of the soil for agricultural production to obtain quality and safe food.

Mechanical support (fastening). The root system of all plants with the exception of hydroponic crops is located in the soil and, depending on the plant and soil conditions,

it is spread to different depths and widths. Through the root, the soil holds the above- ground part of the plant, that is, it represents its mechanical support. In conditions of poorly rooted plants (shallow soils, occurrence of shallow groundwater, impermeable horizon) especially in the case of perennial woody plants, in unfavorable conditions (storm, strong wind, etc.) accidents and economic losses can be caused (damage to houses, cars, as well as agricultural production itself).

Water and nutrients. It is the soil that provides the plants with water and nutrients through the soil solution. More than obvious is the property of soil to retain water and make it available to plants according to their needs.

Of all the 92 chemical elements that occur in nature, 17 are essential, which means that without them plants cannot grow and develop normally. Of these 17 nutrients, 14 are provided through the soil. Carbon, oxygen and hydrogen come from water and air, and the others from the soil. The plant through the root fibers is provided with these nutrients from the soil solution or from the surface of the soil colloidal particles in the form of cations and anions. Energy force for this process is obtained through respiration of the roots. For each kilogram of dry matter produced for the growth and development of the plant (photosynthesis and other needs), between 200 and 1000 kilograms of water are provided from the soil (Plaster J. Edward, 2009).

Oxygen. A large number of representatives of living organisms live in the soil. Except for some microorganisms, all other living organisms, including plant roots, require oxygen. Plants take oxygen from the soil from the soil air, and release carbon dioxide.

Heat. Plant roots develop best at a certain soil temperature (warmth). Together with water, they represent the most important factors of pedoclimate (climate in the soil itself) and are of great importance for cultural plants and the application of various measures, which regulate them.

Soil as a natural asset (resource). Soil covers a certain area, and because it is everywhere, we tend to overlook the fact that soil is a limited natural resource. It is very famous, and a very big message is contained in the sentence written by the American President Franklin D. Roosevelt, cit. in translation "The nation that destroys its soil, destroys itself". Unfortunately, the processes of destruction (destruction) of the soil are mostly unidirectional without the possibility of returning to the original state. In the

historical development of man, the collapse of great civilizations, such as those of the Mayans and Mesopotamia, is known as a result of the destruction of the soil. If we recall the previously mentioned functions of soil, it becomes even clearer why soil is a natural resource. All soil researchers emphasize that soil is a limited and practically very difficult to renew resource.

If it is destroyed, its re-creation from the geological (parent) substrate takes thousands of years, and the processes of soil degradation and loss sometimes occur much faster, that is, in a few seconds or minutes, as is the case with soil erosion or other types of natural or anthropogenic incidents. When it comes to soil, it is very wrong to understand that it has unlimited reserves for biomass production and that there is no need to renew those reserves. This resource is irreplaceable and perishable, which means it should be preserved and, if possible, handed over to future generations in an improved condition.

LOCATION OF THE RESEARCHED AREAS IN DUPNITSA

Dupnitsa, or Dupnica (Bulgarian: Дупница (previously Дубница), pronounced), is a town in Western Bulgaria. It is at the foot of the highest mountains in the Balkan Peninsula – the Rila Mountains, and about 50 km (31 mi) south of the capital Sofia. Dupnitsa is the second largest town in Kyustendil Province.

The town has existed since ancient times. The German traveller Arnold von Harff visited Dupnitsa in 1499 and described it as a "beautiful town". The names Tobinitsa, Doupla and Dubnitsa are mentioned throughout history, the last one used until the Liberation of Bulgaria, when the official name was changed to Dupnitsa. In 1948 the town was renamed Stanke Dimitrov; for a short period in 1949 it was called Marek; the name was changed to Stanke Dimitrov in 1950. After the democratic changes, the old name Dupnitsa was restored.

On 15 October 1902, around 600 women and children fled to the vicinity of Dupnitsa from Macedonia from the attacking Turkish troops.

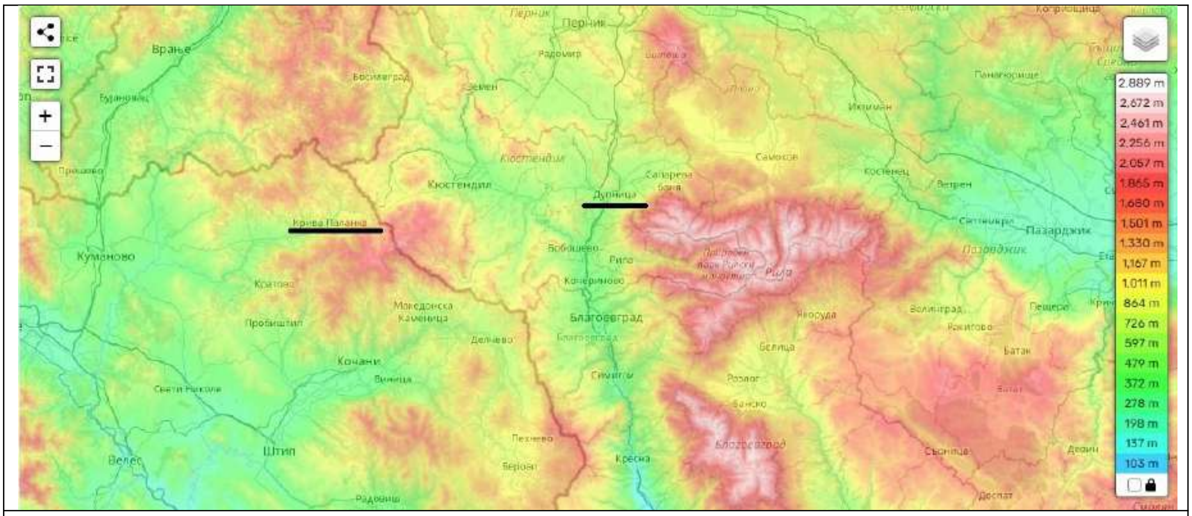
On a hill overlooking the town there is a giant cross, commemorating the Bulgarians who perished in the Balkan wars and World War I. On the same hill there lay the ruins of a medieval fortress.

During World War II over 4,000 Jews from parts of Greece and Yugoslavia annexed by Bulgaria were arrested on 4 March 1943 and deported, some to an internment camp in Dupnitsa. Many of them were from Komotini and Xanthi.[4] After 11 to 12 days in the Dupnitsa camp, on 18 – 19 March they were transferred by train to Lom on the Danube for extermination at Treblinka. As part of the Bulgarian Commissariat for Jewish Affairs's policy of deporting Jews, Dupnitsa also was between June 1943 and September 1944 the site of a ghetto for

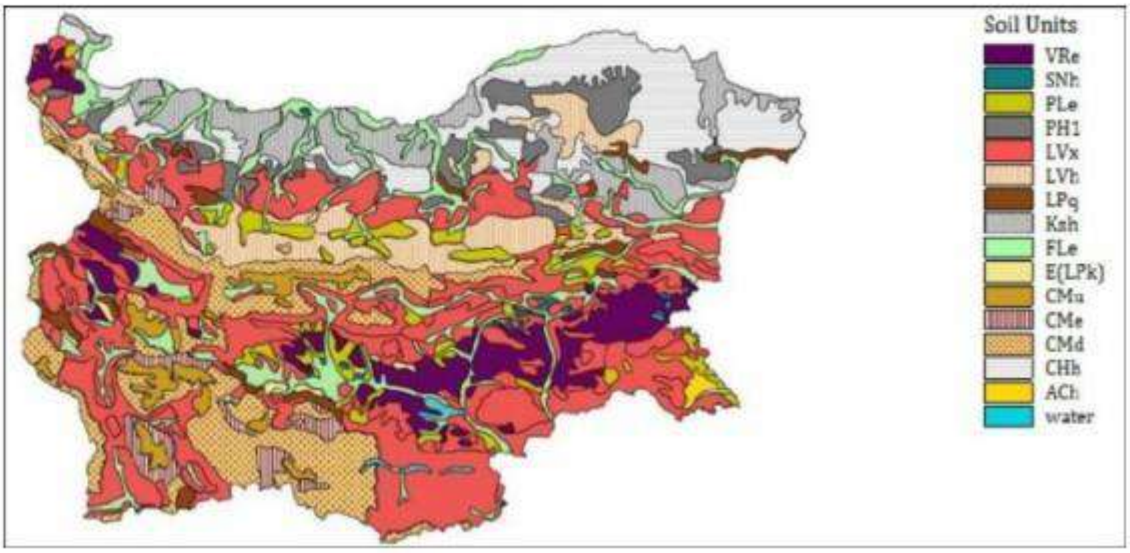
1,624 Jews expelled from Sofia, even though there was ultimately no exterminations of Jews resident within Bulgaria's pre-war borders.

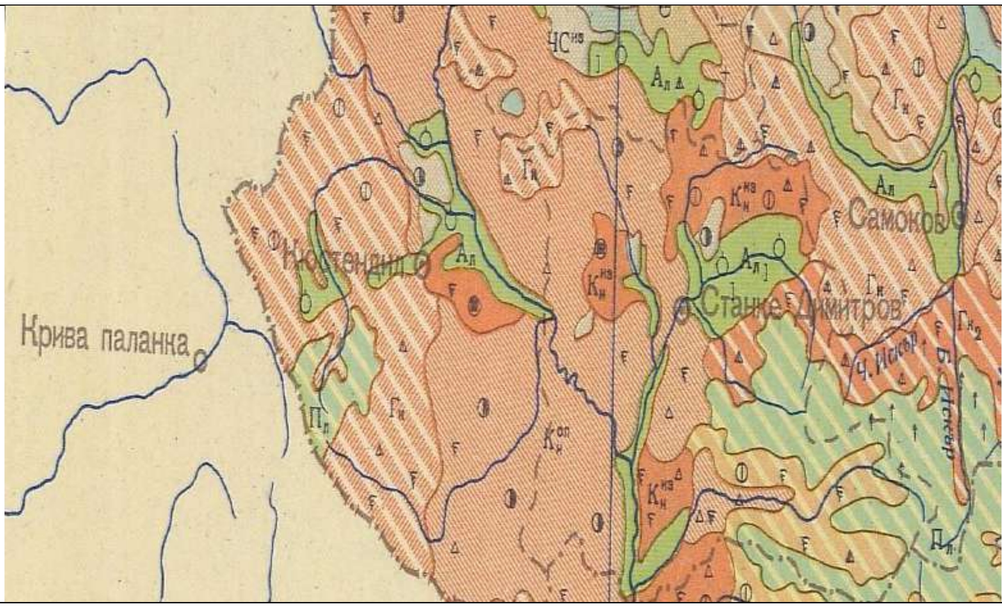
Nowadays Dupnitsa is a fast-developing town combining new buildings with modern architecture with its historical monuments. Because of its beautiful location at the foot of the Rila mountain, the town is marvelous holiday destination. One of the main branches of industry is the pharmaceutical company Actavis (formerly HeFeKa, in Bulgarian ХФК), which gives employment to about 30 to 40 percent of the citizens. Small business is developing rapidly due to the town's economic growth.

Dupnitsa is famous for its cultural festivals. From 1 May to 2 June many festivals are held in the town due to the richness of the Bulgarian holiday calendar. The nightlife is very well developed. There are a lot of local pubs and clubs where young people meet and have fun. A few other popular places for socializing are the recently refurbished Town Park and the Town Garden (Gradska gradina).



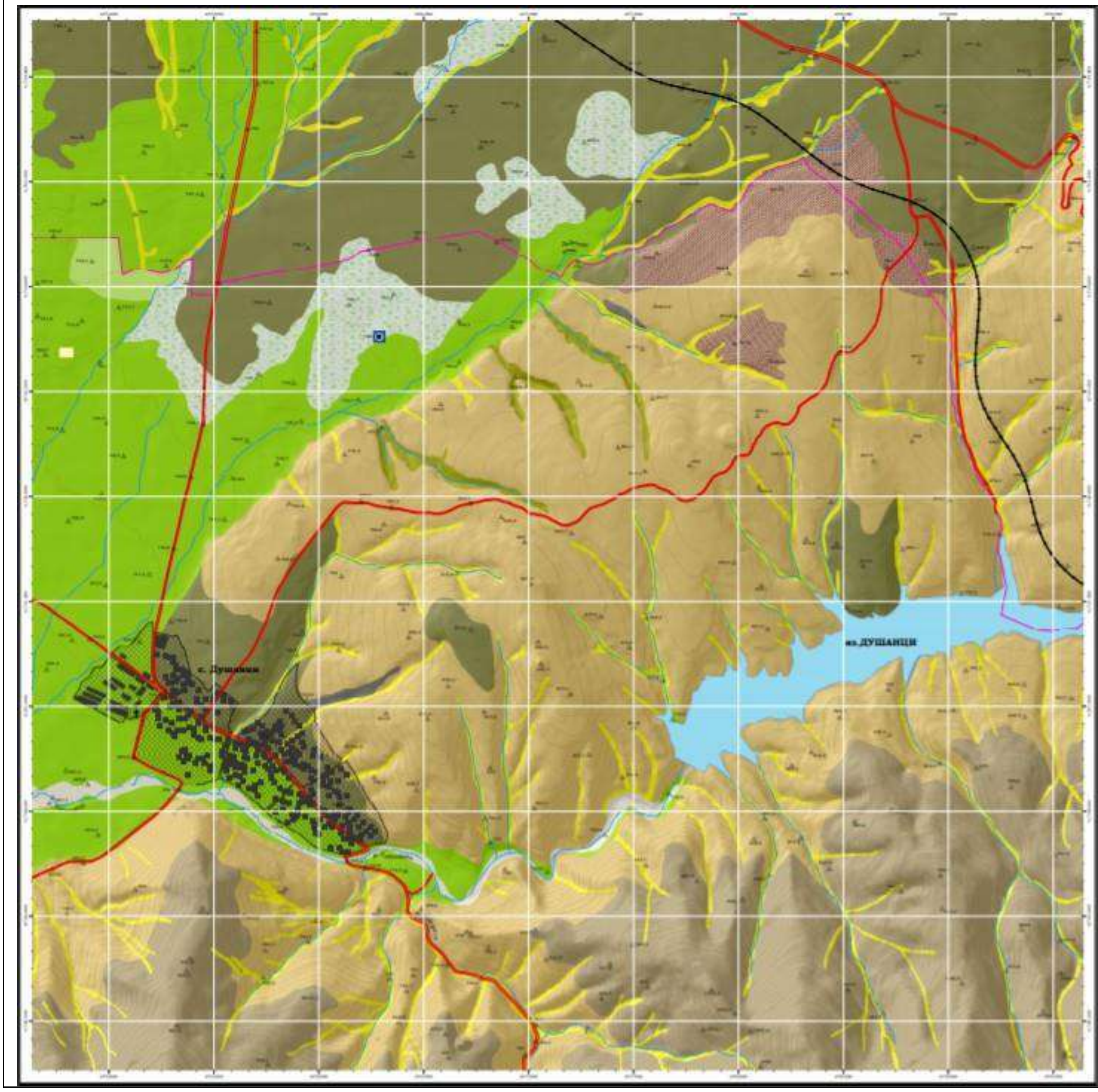
Soil map


Soil Units
VRe
SNh
PLe
PH1
LVx
LVh
LPq
Ksh
FLe
E(LPk)
CMu
CMe
CMd
CHh
ACh
water



Bulgaria is one of the few countries in the world in which the soil cover has been studied in detail and mapped in detail for almost the entire territory of the country. In addition to the soil map, several special purpose registers have been established in the

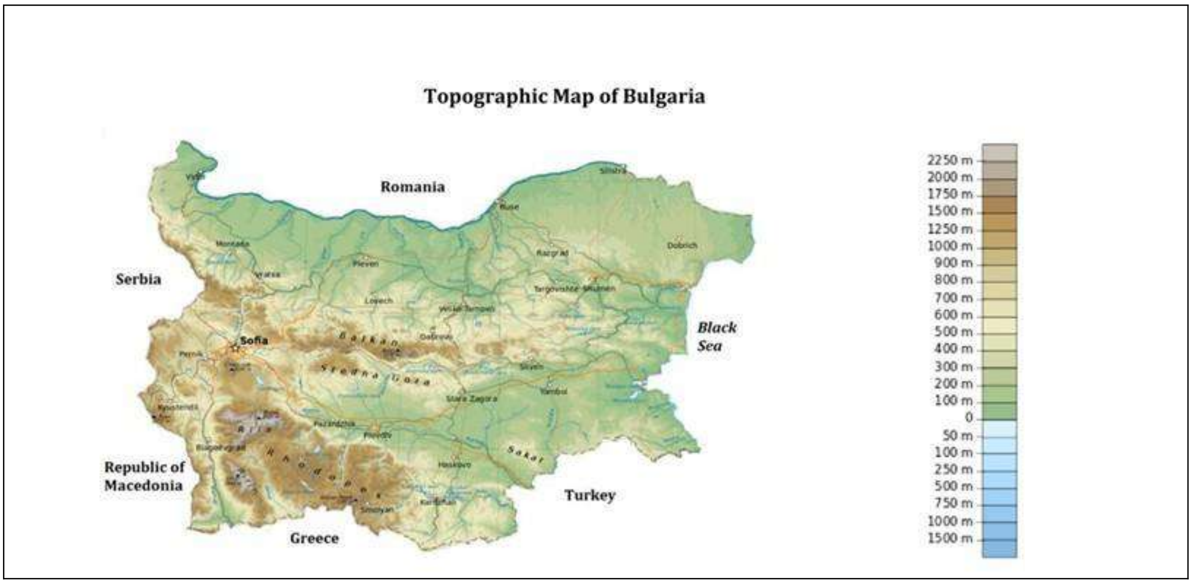
country, which concern the quality of soils and their suitability for different types of agriculture. These are the register of damaged soils, erosion map, small-scale soil map of the country, database of soils in the points of the national monitoring network of I level, national soil archive, register of soil quality and numerous studies of soil profiles and partial mappings for different goals. The Soils of Bulgaria offers a comprehensive analysis of the characteristics of soils and concepts on their magnitude.



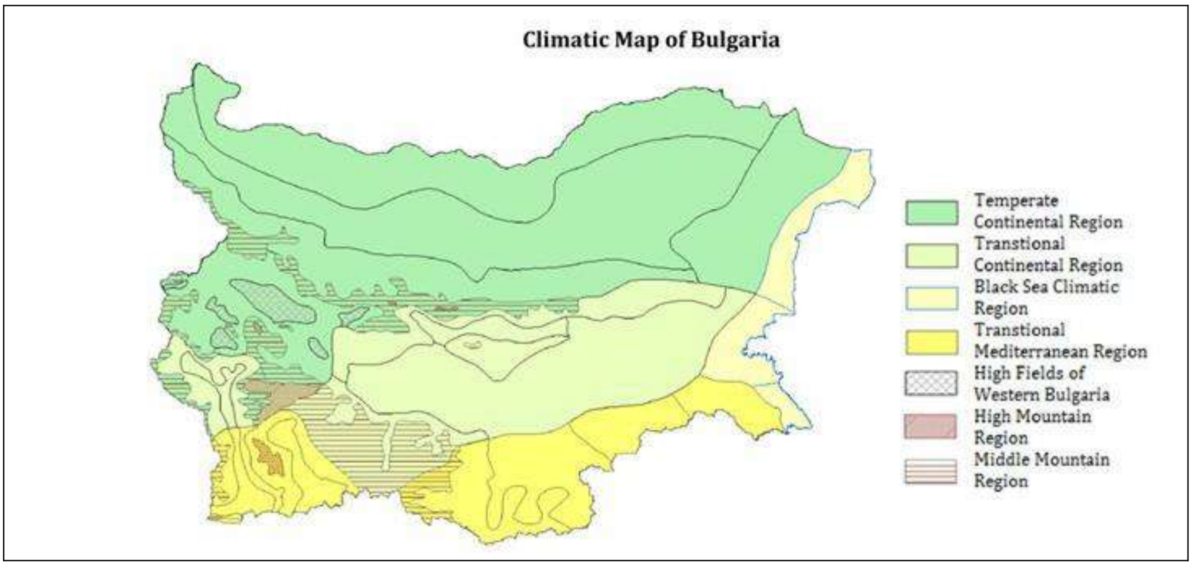
SOIL CLIMATE CHARACTERISTICS

Soils of Bulgaria are developed in different climatic conditions. The country lies between the strongly contrasting temperate continental and Mediterranean climatic zones.

Bulgarian mountains and valleys act as barriers or channels for air masses, causing sharp contrasts in weather over relatively short distances. The continental zone is predominant, because continental air masses flow easily into the unobstructed Danubian plain. Mediterranean influence is spread manly over south parts of the country (Geography of Bulgaria, 2002). Bulgaria is a country with alternation of contrasting seasons. Soils have an annual heating cycle, becoming warm during the summer and then cool to freezing during the winter. The effect on soil is determined by the rates of chemical and biological reactions and evaporation (Shishkov et al., 2014). Climatic conditions have the main impact on vegetation and crop management, which also has influence over soil organic matter content. Soils have the potential to store carbon, in grassland and forest, and particularly in peatlands, through the removal of carbon dioxide during photosynthesis. Soils contain a stock of carbon that is about twice as large as that in the atmosphere and about three times that in vegetation (Smith et al., 2008). The content of organic carbon in soils is increasingly important topic in recent years in relation to climate change, greenhouse gas emissions associated with carbon emissions into the atmosphere.

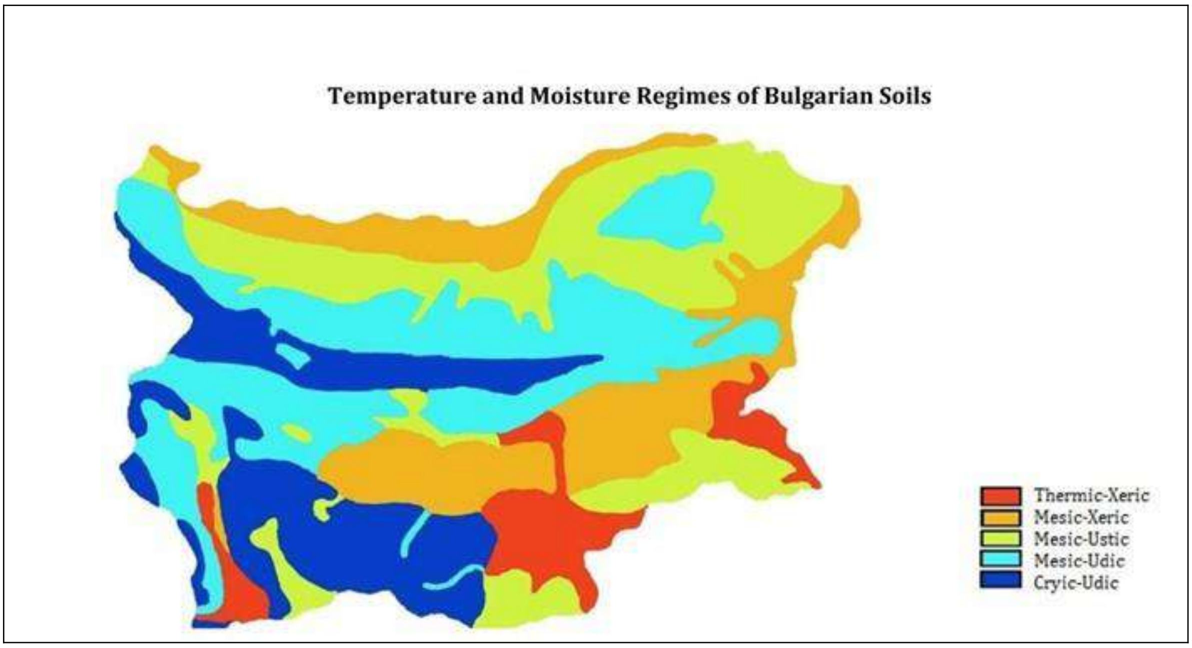


Topographic map of Bulgaria (https://commons.wikimedia.org/wiki/User:Ikonact)



Climatic map of Bulgaria. (Subev et al. (1963) digitized by Dimitrov (2014))

Now we are talking about sequestration of carbon from the atmosphere and holding in the soil to avoid the negative consequences of climate change. The climate is one of the major driving force of soil formation and accumulation of organic carbon (Constatini et al., 2013). Soil climate regimes, expressed via soil moisture and soil temperature regimes, are important in a wide range of applications as soil quality, farming, and ecosystem management. Soils themselves may respond to climate change, leading to both positive and negative effects. Organic carbon in soils is also sensitive to climate change, because this is an interaction between vegetation, climate and parent materials. Soil organic matter is one open dynamic system which is permanently renovated and humus is always in thermodynamic equilibrium with the environmental conditions (Schnitzer and Khan, 1972; Stevenson 1994; Orlov, 1985; Krastanov et al., 2003; Filcheva, 2015). The amounts of soil organic C depend on the relative temperature sensitivities of productivity and soil organic matter decomposition rate. Equations for the temperature dependence of net primary productivity have been widely used, but the temperature dependence of decomposition rate is less clear (Kirschbaum, 1995).



Temperature and moisture regimes of Bulgarian soils. (Boyadjiev, 1989)

The aim of this paper is to focus on influence of different pedoclimatic conditions on soil organic matter content and composition of various areas with different vegetation, management and etc.

FERTILITY AND PRODUCTIVITY OF THE SOIL

For proper growth and development and for obtaining high and quality yields from cultivated plants, several factors are needed, namely: light, heat, water, air, food (nutrients), mechanical support and the absence of inhibitory substances (factors). With the exception of the light factor, all the rest are fully or partially provided by the soil, while all factors are equally important, irreplaceable and should be constantly present in the soil to obtain high, quality and healthy yields. Hence, it can be concluded that soil fertility is a concept that includes all the previously listed factors. Fertility is a new quality property of the soil as a natural-historical body, which distinguishes it from compact rocks. Fertility is connected with the way of using the soil and obtaining yields from the cultivated plants. There are many definitions of soil fertility in the pedological literature. Among them, the most complex is the definition of Filipovski (1993), according to which: Soil fertility is understood as its ability to supply cultural plants throughout their entire life (vegetative period), without interruption, simultaneously with

the necessary amount of food, water , air and other necessary conditions. From the definition, it can be concluded that, in pedology, soil fertility is viewed much more broadly, unlike some other disciplines, where soil fertility is associated only with its provision with a total amount of physiologically active substances (available nutrients). Several types of soil fertility are distinguished: » natural, » anthropogenic and » effective fertility. Some authors mention potential, relative and economic soil fertility. Natural fertility, the name itself says that it represents fertility that the soil gets naturally as a result of its formation under the influence of pedogenetic factors and processes. So, during pedogenesis, unlike the substrate, the formed soil acquires three basic characteristics important for growing plants, namely: to retain water, air and nutrients. During the physical and chemical decomposition of the walls, a loose mass is formed that retains water and air, and with the chemical decomposition of primary minerals, soluble compounds of various biogenic elements, with the exception of nitrogen, are obtained, among other things. With this, conditions are created in the loose mass for the settlement of higher plants, which, together with other living organisms, are the main factor in the synthesis and decomposition of organic matter and in the small (biological) circular movement, which creates the organic part of the soil (organic waste, humus) and biogenic elements accumulate in the surface part of the soil. In all these processes, organisms accumulate large amounts of energy in the soil and enable the existence of future generations of plants and the entire ecosystem. Anthropogenic fertility is characteristic of agricultural soils and is created under the influence of man by taking appropriate agrotechnical and remedial measures. Anthropogenic fertility changes and depends on different human influences, whereby it can increase, but unfortunately, it can also decrease. Both together (natural and anthropogenic) make up the effective soil fertility. It is synonymous with soil productivity, according to Western European and American authors. Soil fertility as its quality property does not represent a constant size. It changes under the influence of various factors and processes that occur in the soil itself, but also in the immediate environment. In the literature, there is another term – productive capacity of the soil, which is related to the yields from cultivated plants. This means that for obtaining high and quality yields, in addition to the quality of the soil, the climatic conditions, the biological capacity of the plants and others are also important.

Productivity of the soil = the amount of yields = a function of the fertility of the soil, the climate, the plant and the action of man.

Soil fertility can have relative importance in relation to productive capacity. It can be explained with the following example: The same soil is not equally productive for every plant, in all climatic conditions and in all systems of agrotechnics. Especially in our climatic conditions, it should be emphasized that in areas where there is no irrigation system, despite all timely and correctly implemented agrotechnical and other measures, the productive capacity of the soil depends on the amount and distribution of precipitation coming from the atmosphere during vegetation, continue to have an impact on the water, air, heat and nutrient regime in the soil, and hence on the amount of yields from plants. In this context, the famous phrase "birth and non-birth years" is very often heard. Since the fertility of the soil is closely correlated with its physical, chemical and biological properties, as well as with the processes taking place in it, it means that soils with high fertility should meet some conditions and characteristics. Of the physical characteristics, of particular importance for fertility are: the depth of the physiologically active layer in which the roots of plants develop, then the mechanical composition, structure, porosity, physical-mechanical and water-air and thermal properties of the soil. Fertile soils have a deep physiologically active and loose layer in which the root develops easily, without any resistance during its penetration through the soil mass. Such soils are loamy in mechanical composition, with a stable granular structure and formed mostly on light loamy and clayey alluvial and deluvial sediments and lake sediments. In fertile soils, there is an optimal amount of physiologically active water, and with it, mobile available nutrients throughout the entire growing season. An important factor for high soil fertility is good porosity and aeration, as well as the presence of stable structural aggregates, which enable the soil to provide optimal amounts of air (oxygen) necessary for root respiration, pedofauna, aerobic microflora and for the intensification of processes of oxidation on which the availability of nutrients for plants depends. Of the physical characteristics, the favorable temperature regime for the development of all life functions of the plants and for the microbial, chemical and physical processes in the soil is significant for the fertility of the soil. Of the chemical characteristics, the following are of

particular importance, directly or indirectly for soil fertility: the amount, composition and forms of humus, the reaction of the soil solution, buffering, the high capacity of adsorption with full dominance of adsorbed Ca^{2+} - ions, the high values of the redox potential, then the content of available forms of the necessary macro and microelements, stimulating substances for plants, as well as the absence of toxic substances. Ripe humus has a very positive effect on soil fertility. Its gradual mineralization allows the release of nutritious biogenic elements important for plant nutrition. Most plants develop optimally in a weakly acidic to weakly alkaline reaction of the soil solution with the simultaneous absence of substances that in higher content have a toxic effect on them: H-, OH-, Al $^{3+}$, Fe^{2+}, Mn^{2+}, and from gases: CH_4, H_2S, H_2 , NH_3, etc. One of the most important factors for soil fertility is the favorable nutrient regime, which implies a sufficient amount of all necessary elements in an available form, as well as their well-expressed dynamics and mobility. All this depends on the content of water, air, heat and activity of microflora and fauna in the soil. Fertile soils with good physical and chemical properties are also characterized by good biological properties. In them there is a sufficient number and representation of useful microflora, micro and macrofauna, whose activity affects the productive capacity of the soil. Also, fertile soils are characterized by the absence of inhibitory factors (impermeable compact horizon, presence of weeds, pests and diseases, toxic harmful substances, etc.). In agricultural soils, the agrotechnical and meliorative measures taken by man to maintain and increase soil fertility are of great importance. The ultimate goal of this is the creation of the so-called cultural soils that have a deep and loose arable layer, a stable granular structure, a favorable nutrient, water, air and heat regime, favorable chemical and microbiological properties and that are free of weeds, pests and diseases. The creation of cultural soils is a complex and complex work that requires a lot of knowledge, work and modern agrotechnical and amelioration measures, such as: » Timely and correct tillage of the soil, including deepening of the arable layer, as well as occasional shaking of the sub-arable layer, which possible occurrence of soil compaction, as a result of incorrect application of heavy machinery, is eliminated; » Improvement of the physical properties, especially of the structure of the soil and its stability, which simultaneously improves the water-air and thermal conditions of the soil;

» Implementation of a correct system of fertilization with the introduction of mineral and

organic (humization), as well as microbial fertilizers according to the needs of the crops and after a previous control of the soil's fertility; » Application of irrigation and drainage;

» Improvement of the chemical properties of the soil, above all the reaction of the soil (calcification of acidic and plastering of alkaline soils); » Elevation of wind protection belts, snow retention and others.

MATERIAL AND METHODS

Five climatic regions are typical for the territory of Bulgaria (Figure 2) – Temperate continental, Transitional continental, Transitional Mediterranean, Black Sea coast, and Mountainous (Subev et al, 1963; Dimitrov, 2014). All these climatic regions have influence over soil temperature and moisture regimes as defined in Soil Taxonomy (Soil Survey Staff, 1999, 2010; FAO, 2006). Boyadjiev (1989) applied the model of Newhall (1972) and identified six different combinations of temperature and moisture regimes over the territory of Bulgaria (Figure 3): Thermic-Xeric, Mesic-Xeric, Mesic-Ustic, Mesic-Udic, Cryic-Udic and Pergelic – Udic. The last one Pergelic - Udic is too small and it is united with Cryic - Udic zone, which is spread mainly on mountainous area of Bulgaria. The Mesic – Udic zone is cover the area of fore-mountains, high fields of central and western Bulgaria and the region of "Ludogorie" of North-East Bulgaria. Soils with Mesic – Ustic regime cover also some regions with lower hilly-mountain relief in South and West Bulgaria. Mesic - Xeric and Thermic- Xeric zones are spread over the lowest and most dry places of Bulgaria, the first one covers northern parts the second one is in the south parts of Bulgaria. In all these pedoclimatic zones of Bulgaria, typical soil profiles data would be given according to specific soil group of WRB (2014).

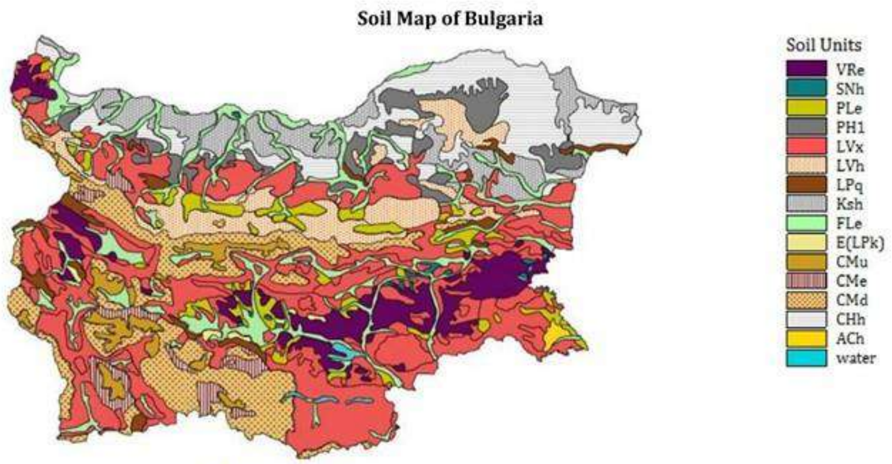


Figure 4. Soil map of Bulgaria. (Kolchakov, 1994), (Soil Units: VRe - Eutric Vertisols; SNh - Haplic Solonetz; PLe - Eutric Planosols; PHl - Luvic Phaeozems; LVx - Chromic Luvisols; LVh - Haplic Luvisols; LPq - Lithic Leptosols; KSh - Haplic Kastanozems; FLe - Eutric Fluvisols ; LPk - Rendzic Leptosols ; CMu - Humic Cambisols; CMe - Eutric Cambisols ; CMd - Dystric Cambisols; CHh - Haplic Chernozems; ACh - Haplic Acrisols)

INTERPRETATION OF THE RESULTS OF ANALYSIS OF THE SOIL SAMPLES

The interpretation of the obtained results implies their use to determine the required amount and type of fertilizer, their ratio, etc., when fertilizing the soil.

The grouping of the obtained results was carried out for the most important elements of soil fertility, and they are the most requested and used in agrotechnical practice:

- (pH) reaction of the soil solution
- the content of carbonates ($CaCO_3$)
- the humus content
- presence of readily available forms of phosphorus P_2O_5 and
- readily available forms of potassium K_2O
- Absorptive capacity (CEC);
- Mechanical composition soil texture
- Water-physical properties

The reaction of the soil is of great importance for the interpretation of the results obtained from the performed soil analyzes and the control of soil fertility, during the use of fertilizers (especially in the selection and type of fertilizer). The reaction is the main condition for the transformation of the mineral fertilizer in the soil and affects the dynamics of availability of nutrients in the soil.

pH is a unit of measure that expresses the degree of acidity or basicity of the soil. Measurement of the pH value of a soil sample is carried out with a pH meter. Acidification of the soil can also be caused by industrial pollutants, especially acid rain in the wider areas of larger energy factories, but some natural processes can also be the cause. Soil reaction affects plants directly through the toxicity of increased concentrations of H+ and OH- ions or indirectly through the influence of changes in a range of soil properties. The intermediate influence of pH is seen through changes in the availability of biogenic elements or through changes in the activity of microorganisms in the soil. Different plant species do not tolerate the same effects of the acidic reaction of the soil. As opposed to acidity, most plants do not tolerate the increased alkalinity of the soil that is typical of an arid (dry) climate.

Soil classification according to pH value in H_2O

Soil reaction	*pH value in H_2O*
very acidic	***< 4.5***
acidic	***4.51-5.50***
slightly acidic	***5.51-6.50***
neutral	***6.61-7.20***
slightly alkaline	***7.21-8.00***
alkaline	***> 8.01***

The content of carbonates ($CaCO_3$) is important for the application of organic fertilizers and some mineral fertilizers. The presence of calcium carbonate affects the reaction of the soil, in providing optimal conditions for the mineralization of organic matter in the soil and for the correct selection of mineral fertilizers (correct form and presence of active substances, especially in the case of phosphorus fertilizers and trace elements).

According to the content of total CaCO3, the soils can be:

carbonated	***0 %***
slightly carbonated	***0-5 %***
medium carbonate	***5-10 %***
very carbonated	***> 10 %***

Hummus. The content of humus in the soil affects its fertility due to its positive properties. The organic matter in the soil originates from the remains of living organisms, which are more or less decomposed and then rebuild the organic compounds of the soil.

The organic matter in the soil represents:

– a source of nutrients for plants;

– basic actor of the soil structure;

– stability of soil aggregates;

– soil cultivation factor;

– helps in the movement of water and air in the soil;

– helps in water retention;

– prevents erosion;

– has a buffering effect (pesticides, nutrients, etc.);

– prevents the leaching of nutrients from the zone of the root system into the deeper soil layers;

– gives color to the soil (warming).

The amount of organic matter is small compared to the rest of the soil, but it is still essential because:

• determines the difference between soils;

• affects many significant physical and chemical properties of the soil;

• represents a basic source of energy for the life activity of microorganisms living in the soil.

According to the humus content, soils are classified into groups:

Group	*Humus content in %*		
	Sandy	*silt*	*Clay*
High	> 2,5	> 4.00	> 5.0
Middle	1,0 - 2,5	1.5 - 4.0	2.0 - 5.0
Low	1,0	1.5	2.0

Total nitrogen content

Nitrogen occupies a special place in the group of essential elements. It originates from the atmosphere (N_2), but is adopted in mineral form and is therefore included in the group of mineral elements. It is a component of proteins, nucleic acids, photosynthetic pigments, amines, amides and other compounds that form the basis of life, and therefore the chemistry of this element is the most important part of plant nutrition. The importance of nitrogen is even greater in that it can be used by only a small number of organisms from the atmosphere (where it is 78.1%) in the gaseous state (N_2). A huge amount of energy (946 KJ = 226 Cal) is required to convert the molecular form of nitrogen to ammonia and nitrates, in which form plants adopt it. On the other hand, nitrogen easily returns to the molecular state in which it is most stable, so it is easily lost from the soil. Nitrogen in the soil is found in the form of organic and inorganic compounds. Inorganic nitrogen N comes in the form of nitrates (NO_3^-) and ammonium compounds (NH_4^+). Nitrogen in the soil is mostly found at a depth of 0-20 cm, in insignificant amounts, namely: 3-8 ppm NH_4 and 3-10 ppm NO_3. The largest amounts of nitrogen amount to

3000-4000 kg/ha and are mainly bound in the organic matter. However, some soil nitrogen is fixed in the form of ammonium ions in clay minerals and organic matter.

The organic part of nitrogen is represented by humus and incompletely decomposed plant and animal remains.

The content of nitrogen in the soil depends primarily on the amount of humus, which contains an average of 5%, and in dry areas up to 10% of nitrogen.

Nitrogen in the soil is found in these forms:

- In the form of ammonium or nitrate compounds, but only 1-2% of the total nitrogen;
- In organic compounds, which are easily decomposed, giving substances capable of nitrification (amino acids and amides);
- In organic compounds that are slowly decomposed by soil microorganisms.

Easily available phosphorus P_2O_5. The grouping of soils according to the content of readily available phosphorus is of great importance for the application of mineral fertilizers. According to the Al method, the grouping of soils based on availability of readily available phosphorus is carried out in the following way:

Security	*Content of P_2O_5 /mg/100g*	
	pH > 6	*pH < 6*
low secured	< 8	< 5
poor	8 - 10	6 -10
medium	10 - 20	10 -16

rich	20 - 35	16 - 30
very rich	> 35	> 30

The determination of readily available phosphorus in the soil is aimed at determining the provision of the soil with this essential element for plant nutrition, and on that basis, the required amount of phosphorus fertilizers is determined.

Phosphorus is a non-metal that occurs in nature, soil and plants in pentavalent form. It is part of important organic compounds such as nucleoproteins, phospholipids, enzymes and many others. The phosphorus cycle consists of the breakdown of phosphorus compounds in the soil, their uptake by plants, and the regeneration of soil minerals. As many as 170 minerals containing phosphorus are known, and they are scattered throughout all igneous rocks.

Phosphorus in the soil comes as organic and mineral phosphorus. The content of organic phosphorus depends on the organic matter in the soil. About 50% of organic phosphorus is in the form of phytins, nucleic acids (DNA and RNA) and lecithin. Phytin comes from the seeds of plants, and some of it is created through microbial processes in the soil. Compounds of phytin with Ca, Mg and Al are hardly soluble. Organic phosphorus enters the soil through barnyard and green manure, compost, forest litter, root debris, and dead soil-dwelling microorganisms, insects, and animals. This phosphorus becomes accessible to plants after decomposition, that is, after the mineralization of organic substances.

Changes in phosphorus compounds in the soil occur under the biological influence of plants and microorganisms and colloidal-chemical processes. The direction and character of these processes depends on the reaction of the environment (pH), the content of carbonates and other factors.

Plants also play a role in the mobilization of phosphorus compounds in the soil. Some crops make good use of hard-to-dissolve phosphates - phosphorite and apatite, because they acidify the soil solution quite a bit with their roots, secreting a lot of H - ions, i.e. various acids. These include lupine, buckwheat, peas, while cereal crops use these hard-to-dissolve phosphates much more difficult.

Phosphorus fertilizers are better used when they are introduced locally into the zone of the root system (in rows) than when they are scattered over the entire surface, because the root receives phosphorus only from the soil with which it is in direct contact with it. Microorganisms that secrete organic acids play the biggest role in the breakdown of mineral phosphates. These processes in the soil are also affected by mineral acids that occur during various microbiological processes, as well as from the application of various physiologically acidic manures (KCl, (NH4)2SO4). Organic phosphorus is also broken down by microbial processes. The transformation of phosphorus from humus is more difficult and the same phosphorus is less available to plants, while that from stable and green waste and from organic plant residues decomposes faster.

Easily available potassium K_2O. When grouping the soil according to the content of readily available potassium (Al method), the mechanical composition of the soil and

the content of humus are taken into account, due to the interdependence of these two parameters.

Security	***Content of K_2O /mg/100g***		
	Sandy	***silt***	***Clay***
low secured	< 10	< 8	< 5
poor	10 -15	8 -12	5 - 8
medium	15 - 24	12 - 20	8 -12
rich	24 - 40	20 - 35	12 - 20

very rich	> 40	> 35	> 20

The determination of readily available potassium in the soil aims to determine the provision of the soil with this essential element for plant nutrition. The amount of potassium fertilizers required will be determined based on its presence in the soil.

Potassium is an alkali metal that is very widespread in nature. In the soil and in plants, it is found only as a monovalent cation (K^+) with reducing properties. It is not included in the composition of organic substances, but is loosely bound mostly to proteins. Potassium has the role of a specific activator, that is, a modulator of enzyme activity.

The potassium in the soil originates from the rocks and minerals, which provided the material for its formation. Some of the potassium from rocks and minerals remains in the soil in a poorly soluble form, and only to a lesser extent is in a form available to plants.

Potassium in the crystal lattice of minerals constitutes the main reserve of potassium in the soil. During the decomposition of minerals under the influence of various factors, potassium becomes available to plants. Such decomposition is carried out under the influence of acids, water, temperatures and certain bacteria.

Exchangeable potassium is bound to the surface of organic colloids and clay particles. Exchangeable potassium accounts for less than 1/100 parts of total potassium, but directly or indirectly, is an important source of potassium for plant nutrition.

Potassium in the soil solution or soluble potassium is found in the form of potassium ions (K^+). Soluble potassium is directly accessible to plants, but those amounts are not sufficient for high yields. In organic matter (humus) there is less than 0.1% readily available potassium (K_2O). Harvested organic residues contain certain amounts of K: cereals 9 – 15 kg/ha, trench crops 30 – 48 kg/ha, alfalfa 64 kg/ha, clover 75 kg/ha. For

example, plowing in cut corn stalks, leaf and sugar beet heads returns significant amounts of potassium and reduces the need for potassium fertilizers.

RESULTS OF SOIL COMPOSITION

The analyzed soil profiles are presented tabularly.

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER			I DUPNITSA 6270 kv.m		
Laboratory number			1	2	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the Turin method, modified	1,90	1,34	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,126	0,109	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	0,00	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	5,87	5,75	/
6.	**Available P_2O_5**	AL Method	4,87	4,72	[mg/100 g soil]
7.	**Available K_2O**	AL Method	10,32	9,98	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	23,49	20,93	[%]
9.	**Fine sand**	International pipette B – method in	19,11	26,97	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	42,6	47,9	[%]
11.	**Clay < 0.002mm**	International pipette B – method in	46,8	49,9	[%]
12.	**Silt 0.0020.02m**	International pipette B – method in	10,6	2,2	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	57,4	52,1	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**II DUPNITSA 848 kv.m**

Laboratory number			1	2	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the Turin method, modified	1,09	1,12	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,098	0,093	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	9,58	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	5,79	6,83	/
6.	**Available P_2O_5**	AL Method	4,73	12,23	[mg/100 g soil]
7.	**Available K_2O**	AL Method	9,60	19,38	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	21,51	32,98	[%]
9.	**Fine sand**	International pipette B – method in	32,39	37,12	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	53,9	70,10	[%]
11.	**Clay < 0.002mm**	International pipette B – method in	46,1	24,8	[%]
12.	**Silt 0.0020.02m**	International pipette B – method in	0,0	5,14	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	59,2	29,9	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**III DUPNITSA 2506 kv.m**

Laboratory number			**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
14.	**Soil preparation**	МКС ISO 11464:2015	/	/	/
15.	**Organic mater**	Determination of organic C and humus by the	2,16	2,10	[%]
16.	**N (Total nitrogen)**	*ISO -11261	0,126	0,103	[%]
17.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	0,00	[%]
18.	**pH in H_2O**	МКС ISO 10390:2015	6,67	6,59	/
19.	**Available P_2O_5**	AL Method	11,36	12,16	[mg/100 g soil]
20.	**Available K_2O**	AL Method	16,06	23,63	[mg/100 g soil]
21.	**Coarse sand**	International pipette B – method in	47,22	30,67	[%]
22.	**Fine sand**	International pipette B – method in	6,28	31,43	[%]
23.	**Total sand 0.002-2mm**	International pipette B – method in	53,5	62,1	[%]
24.	**Clay < 0.002mm**	International pipette B –	41,2	32,1	[%]
25.	**Silt 0.0020.02mm**	International pipette B – method in	5,3	5,8	[%]
26.	**Silt + Clay <0.02mm**	International pipette B – method in	46,5	37,9	[%]

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RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**IV DUPNITSA 1573 kv.m**

Laboratory number			**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the	1,76	1,12	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,116	0,096	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	0,00	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	6,17	6,50	/
6.	**Available P_2O_5**	AL Method	13,12	7,41	[mg/100 g soil]
7.	**Available K_2O**	AL Method	25,27	35,28	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	41,84	40,36	[%]
9.	**Fine sand**	International pipette B – method in	47.46	32.54	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	89.3	72.9	[%]
11.	**Clay < 0.002mm**	International pipette B –	10,7	27,1	[%]
12.	**Silt 0.0020.02mm**	International pipette B – method in	8,6	7,5	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	10,7	27,1	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**V DUPNITSA 4406 kv.m**

Laboratory number			**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the	0,95	0,90	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,071	0,056	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	6,25	0,00	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	6,64	6,81	/
6.	**Available P_2O_5**	AL Method	5,07	7,52	[mg/100 g soil]
7.	**Available K_2O**	AL Method	25,11	14,94	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	37,44	42,40	[%]
9.	**Fine sand**	International pipette B – method in	36.06	24,90	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	73.5	67,30	[%]
11.	**Clay < 0.002mm**	International pipette B –	26,5	20,8	[%]
12.	**Silt 0.0020.02mm**	International pipette B – method in	6,6	20,6	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	26,5	32,70	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**VI DUPNITSA 4309 kv.m**

Laboratory number			**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the Turin	2,27	1,13	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,124	0,116	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	13,32	11,24	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	7,95	7,94	/
6.	**Available P_2O_5**	AL Method	6,05	7,68	[mg/100 g soil]
7.	**Available K_2O**	AL Method	22,11	15,70	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	36,59	47,67	[%]
9.	**Fine sand**	International pipette B – method in	38,81	26,83	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	75,40	74,50	[%]
11.	**Clay < 0.002mm**	International pipette B –	15,6	10,7	[%]
12.	**Silt 0.0020.02mm**	International pipette B – method in	9,00	14,8	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	24,60	25,50	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**VII DUPNITSA 589 kv.m**

Laboratory number			**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the Turin	2,46	2,10	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,131	0,117	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	0,00	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	6,61	6,39	/
6.	**Available P_2O_5**	AL Method	6,03	5,95	[mg/100 g soil]
7.	**Available K_2O**	AL Method	15,62	25,87	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	46,1	47,9	[%]
9.	**Fine sand**	International pipette B – method in	31,80	27,90	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	77,90	75,80	[%]
11.	**Clay < 0.002mm**	International pipette B –	11,80	10,06	[%]
12.	**Silt 0.0020.02mm**	International pipette B – method in	10,3	14,14	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	22,10	24,20	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**VIII DUPNITSA 1883 kv.m**

Laboratory number			**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the	1,12	0,98	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,087	0,076	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	0,00	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	6,04	6,31	/
6.	**Available P_2O_5**	AL Method	6,63	7,12	[mg/100 g soil]
7.	**Available K_2O**	AL Method	27,95	15,94	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	39,54	42,40	[%]
9.	**Fine sand**	International pipette B – method in	21,56	24,90	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	61,10	67,30	[%]
11.	**Clay < 0.002mm**	International pipette B –	25,2	20,6	[%]
12.	**Silt 0.0020.02mm**	International pipette B – method in	13,17	20,8	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	38,90	32,70	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**IX DUPNITSA 878 kv.m**

Laboratory number			**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the	1,56	1,23	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,106	0,104	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	0,00	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	6,12	6,17	/
6.	**Available P_2O_5**	AL Method	8,90	6,34	[mg/100 g soil]
7.	**Available K_2O**	AL Method	19,30	21,54	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	21,56	24,90	[%]
9.	**Fine sand**	International pipette B – method in	39,54	42,40	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	61,10	67,30	[%]
11.	**Clay < 0.002mm**	International pipette B –	25,2	20,6	[%]
12.	**Silt 0.0020.02mm**	International pipette B – method in	13,17	20,8	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	38,90	32,70	[%]

RESULTS FROM PHYSICAL - CHEMICAL EXAMINATION OF SOIL

REQUEST NUMBER	**X DUPNITSA 1818 kv.m**

	Laboratory number		**1**	**2**	
No.	**Parameter**	**Method**	**Result Depth 0-30 cm**	**Result Depth 30-60 cm**	**Measure unit**
1.	**Soil preparation**	MKC ISO 11464:2015	/	/	/
2.	**Organic mater**	Determination of organic C and humus by the	2,46	1,87	[%]
3.	**N (Total nitrogen)**	*ISO -11261	0,126	0,153	[%]
4.	**Total $CaCO_3$**	* Volumetric ISO 10693	0,00	0,00	[%]
5.	**pH in H_2O**	MKC ISO 10390:2015	6,67	6,59	/
6.	**Available P_2O_5**	AL Method	17,36	15,16	[mg/100 g soil]
7.	**Available K_2O**	AL Method	18,36	22,89	[mg/100 g soil]
8.	**Coarse sand**	International pipette B – method in	47,22	30,67	[%]
9.	**Fine sand**	International pipette B – method in	6,28	31,43	[%]
10.	**Total sand 0.002-2mm**	International pipette B – method in	53,5	62,1	[%]
11.	**Clay < 0.002mm**	International pipette B –	41,2	32,1	[%]
12.	**Silt 0.0020.02mm**	International pipette B – method in	5,3	5,8	[%]
13.	**Silt + Clay <0.02mm**	International pipette B – method in	46,5	37,9	[%]

The mechanical composition or texture of the soil depends on the substrate from which the soil is formed and on the processes that take place in it during pedogenesis and evolution. The soil from the substrate receives particles of the most different dimensions: from the smallest, colloidal to the largest, stony, and that is why it is called a polydisperse system. Each individual particle in the solid phase of the soil is referred to as a primary particle or mechanical (granulometric) element, in contrast to the secondary elements which are called structural aggregates. The mechanical elements represent elementary (primary) soil particles of different sizes which, under the influence of weak forces (under the pressure of the fingers or a weak jet of water), do not divide or destroy. When determining the mechanical composition of the soil, it is impossible to measure the dimension of each particle separately and therefore they are grouped (fractionated) into groups, i.e. fractions, whereby the amount of different fractions in the soil is determined by the mechanical analysis. The term fraction means a group of mechanical elements with a certain dimension, and mechanical analysis means the determination of the content of the different fractions in the soil. In the laboratory, when a mechanical analysis of the soil is done, it is previously sieved through a sieve with openings of 2 mm, and organic substances are removed. After completing the analysis, the separate fractions of mechanical elements expressed in % are obtained (for example, 30% sand, 35% dust and 35% clay). In this way, the mechanical composition of the soil is determined. The mechanical composition or texture of the soil means the content of various fractions of mechanical elements expressed in weight, i.e. mass percentages. In different countries of the world there are different classifications of mechanical elements. In our country, the classification of the International Union of Soil Sciences (IUSS – The International Union of Soil Sciences) is accepted, according to which the mechanical elements are divided into two groups with several fractions.

Each fraction of the group of gravel and fine soil has its own characteristics. The skeleton (stones and gravel) is obtained by physical decomposition. It consists of pieces of undisintegrated rock with a rounded shape (if transported over a longer distance) or with sharp edges if the soil was formed in situ ("in situ"), or transported over a short distance. According to the mineralogical composition, it can be carbonate, silicate, quartz and mixed. This fraction is more represented in mountain soils, and it is also found in

agricultural soils formed on coarser alluvial, deluvial or lake sediments. The small presence of gravel and stones improves the growth and development of agricultural crops on clay soils. But if their presence is greater than 20%, then there is a negative impact on the cultivation of agricultural crops. Such surfaces are cleaned of large stones and gravel so as not to damage the mechanization during soil cultivation. Soils rich in skeleton retain water poorly, heat up more strongly in summer, are washed more strongly and are poor in nutrients. The sand fraction is obtained by physical decomposition. It is very permeable, does not retain water, in its dry state it is unbound and the grains cannot come together, and it does not raise water at all or very little by capillary action, it is not plastic and it is not sticky.

It occurs in all soils in a greater or lesser percentage (from 5 to 10 %, even over 95 %), and the most favorable content in the soil is 40 to 70 %. In clay soils, it reduces the negative properties of clay. By mineralogical composition, sand can be quartz, carbonate, silicate and mixed. Quartz sand consists of SiO_2, is infertile, plays only a mechanical role and constitutes the skeleton of the soil. Silicate consists of silicate and aluminosilicate minerals, it decomposes slowly and can yield some clay and various salts, including nutrients. That is why it is marked as "potentially" fertile. Sand-rich soils are dry, warm, highly permeable and poorly water-retaining, and poor in nutrients. The dust fraction, according to its properties, makes a transition between sand and clay. It is mostly obtained by physical decomposition. It holds it better, but lets the water through less than the sand. The powder is characterized by a high capillary absorption of water, does not or very poorly settles, is weakly sticky and weakly plastic. In the dry state it is hard (bound) and has the appearance of flour. The highest percentage of dust is found in soils formed on loess and dusty alluvial deposits. According to mineralogical composition, it mostly contains quartz and opal, less mica, and maybe calcite and dolomite. Clay is formed by chemical decomposition. It barely lets water through, but it retains it well, and it slowly raises the water by capillary action. In a wet state, it is plastic and sticky, and in a dry state it contracts, cracks and hardens strongly. Compared to other fractions, it retains the most water and nutrients. This is due to the small size of the particles and the permanent electrified charge. Different soils differ in terms of the

content and percentage of sand, dust and clay fractions. In that context, several textural classes of soils are distinguished.

All classes are usually grouped into three basic groups, so sandy, loamy and clayey soils are distinguished. Sandy soils are well aerated, have good water permeability, but low water retention, are easily heated and are therefore labeled as "dry and hot" soils. They are characterized by low plasticity, stickiness and cohesion. They are easy to process, have a low content of clay and humus, low absorption capacity, i.e. retain very little nutrients in them.

Clean sands can be used in forestry, and sandy soils with more clay can also be used in agriculture. Their fertility is increased by increasing the content of clay and humus, and by applying artificial fertilizers that should be added more often and in small doses to avoid the risk of leaching and environmental pollution. Clay soils have completely opposite properties compared to sandy soils. They are characterized by poor physical and relatively good chemical properties. They have high water retention, but low water permeability and aeration. They are more difficult to heat and therefore are often labeled as "wet and cold" soils. They are characterized by high plasticity, stickiness and swelling in the wet state and hardness, compactness and cracking in the dry state. Soils with a high content of clay (especially from the group of smectites, montmorillonite) are designated as "heavy" soils. They have a relatively short interval of high-quality tillage and at the same time provide strong resistance. As a result of the unfavorable water, air and heat regime, they have reduced biological activity. Also, these soils are problematic, both during irrigation and drainage. Due to the high content of clay and better humus, they have a high absorption capacity, and are distinguished by a higher buffering capacity. They can be fertilized less often, but with higher doses of phosphorus and potassium fertilizers, without the risk of washing them away.

Loamy soils constitute the transition between sandy and clayey soils. They have good physical and chemical properties. They contain approximately equal amounts of sand, dust and clay. They pass and retain water well and are well aerated. When they have a favorable humidity, they give good processing quality and are therefore labeled as "medium heavy" soils. They have a good absorption capacity, contain and retain nutrients well, and can be fertilized with high doses of fertilizers without the risk of them being washed away.

Significance of mechanical composition for other soil properties for agricultural production

According to what has been said so far, the texture of the soil is of great importance for the genesis and evolution of the soil, for the physical, physico-mechanical and absorptive properties of the soil, and it has immediate importance for the agricultural production. In nature, the mechanical composition is one of the most stable soil characteristics. The water, air and heat regime of the soil depends on the mechanical composition. On the one hand, the water-air regime also depends on the mineralogical composition of the clay. A soil with 40% montmorillonite type clay has much worse physical properties than a soil containing 70% kaolinite. On the other hand, two clay soils, with the same percentage of clay and other fractions, may have different water, air and heat conditions if they have different structures. Structureless clay soils have poor, and clay soils with a stable grain structure have good physical properties. The physical properties of soils with the same clay content are better if there are more adsorbed Ca2+- ions in the soil adsorptive complex than H+ and Na+-ions. Also, with the same percentage of clay, if in one soil the mechanical elements have a plate and disk shape, the stickiness, plasticity and cohesion are more pronounced, compared to the other one that has spherical mechanical elements. Some authors consider that the mechanical composition represents one of the morphological properties of the soil. In the field, by digging the soil profile and during its morphological description, the mechanical composition of the soil can be qualitatively determined by feeling and crushing the dry soil and by rolling and crushing the wet soil under the fingers. In this way, at least 5 textural classes can be determined: sandy, sandy-loamy, loamy, loamy-loamy and clayey. The choice of cultural plants for sowing and planting depends very much on the mechanical composition of the soil. So, on soils with a lighter mechanical composition, it is better to grow root and tuber crops, tobacco, potatoes and early garden crops. The application of various ameliorative and hydrotechnical measures are also closely correlated with the mechanical composition. Soils with a lighter mechanical composition need to be irrigated more often in smaller quantities, unlike "heavier" soils. This is also related to the placement of the irrigation and drainage systems (the distance of the channels, drains, etc.), as well as to the choice of the irrigation method (artificial rain,

drip irrigation, surface irrigation, etc.). The processing interval for soils with a lighter mechanical composition is longer, and for clay soils it is very short. The higher content of clay in the soil causes greater resistance during processing, thus increasing the costs of this operation. Processing, especially deep processing, can change the mechanical composition when mixing two layers or horizons with different mechanical composition. The mechanical composition can be modified by cleaning the skeleton from the soil, by leveling the soil for irrigation, etc. Chemical meliorations, i.e. the amount of lime ($CaCO_3$) for calcification of acidic soils and of gypsum ($CaSO_4$) for plastering of salty soils is greater if the soil contains more clay. The choice and doses of mineral fertilizers depend on the mechanical composition of the soil. In "lighter" soils, nutrients are washed away more and therefore more frequent fertilization with lower doses is required. Eutrification of groundwater is higher in these soils. With clay soils, there is no danger of nutrients being washed away, and therefore they can be fertilized less often and in larger doses. The mechanical composition is also important for the erodibility of the soil. Other things being equal, soils richer in dust and non-structural are more strongly eroded. The textural differentiation of the soil (the profile) is also of great importance for agricultural production. Strong textural differentiation (differences in mechanical composition between horizons) is detrimental. Plants require as homogeneous an environment as possible for their growth and development. Therefore, the farmer tends to create a homogeneous and deep arable layer. Finally, if it is economically justified, man can change the mechanical composition of the soil in the direction of improving its properties by adding sand to clay soils, that is, clay to sandy soils. This experience proved to be very positive in Germany, by covering sandy soils with a loess layer of 20 cm (2 000 m^3 /ha loess).

Based on the soil-climatic conditions of the investigated area, the following plant species are recommended (given in a table).

1. *Cedrus atlantica*
2. *Picea pungens*
3. *Pinus sylvestris*
4. *Acer rubrum*
5. *Fagus sylvatica*
6. *Fraxinus excelsior*
7. *Platanus orientalis*
8. *Querqus rubra*
9. *Juniperus horizontalis "Wiltonii"*
10. *Berberis thunbergii "Carmen"*
11. *Buddleja davidii*
12. *Cornus alba "Sibirica"*
13. *Cotinus coggygria*
14. *Cotoneaster horizontalis*
15. *Ilex altaclerensis "Golden king"*
16. *Lonicera nitida "Aurea"*
17. *Photinia serrulata "Red Robin"*
18. *Sambucus nigra f. porphyrophylla*
19. *Carex morrowii 'Aureovariegata'*
20. *Erica carnea*
21. *Hemerocalis fulva*
22. *Hosta hybrida*
23. *Panicum virgatum*
24. *Taxus baccata "Fastigiata"*

25. Fagus sylvatica
26. Platanus orientalis
27. Querqus cerris
28. Querqus rubra
29. Juniperus horizontalis "Wiltonii"
30. Berberis thunbergii "Carmen"
31. Buddleja davidii
32. Cornus alba "Sibirica"
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40. Taxus baccata "Fastigiata"

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FOTOS

	
	

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