Content

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Interreg IPA Cross-border Cooperation Bulgaria - Turkey Programme (2014 - 2020) – 2020,CCI No 2014TC16I5CB005.

1. Introduction - description of the project and nature of the study

"Save nature to save the future" is a project co-financed by the European Union through the Cross-border Cooperation Program INTERREG - IPA Bulgaria - Turkey 2014 - 2020, in which partners are the Chamber of Agriculture - Meric and CEIBG Haskovo.

The main goal of the project is the protection of soils in the cross-border regions of Bulgaria and Turkey. Soil, as a component of the environment, is an indispensable, limited and practically irreplaceable natural resource. It is extremely important to preserve it for future generations because it is key to the food security of the population.

The functions of the soil are extremely important for nature and humanity, and their disruption has a global impact. Its main purpose is to provide conditions for the development of agricultural crops, and its fertility - the basis of agricultural production.

In the 21st century, with constant technological progress and a growing population, there is a crisis of natural resources such as minerals, fuels, and soil. The reduction of soil resources is usually the result of their intensive exploitation. The soil is subjected to various forms of damage, the most common being chemical pollution with heavy metals, various forms of

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degradation processes such as erosion, acidification, and salinization. It requires protection from harmful effects, destruction, and its sustainable use. This is the purpose of the study, which is the basis of the project - to inform the public about the consequences of negligent treatment of soils and the possibilities for their prevention.

We do not own the land. It is a gift from nature. We have inherited it from our ancestors, and we are obliged to pass it on to the next generations. For this reason, the state of soil resources and soils in the cross-border region of Bulgaria - Turkey - Haskovo region are the subject of this study under the project "Save nature to save the future”. To realize it, soil samples were taken from different lands. Soil analyzes were performed with the help of the electronic mobile laboratory for soil analysis. The equipment was purchased under the project and provides accurate and timely results for fifteen soil factors, including the availability of macronutrients and critical micronutrients. It makes it possible to determine the nutrient needs of soils in Haskovo district, to help proper fertilization and achieve optimal yields.

With the help of the equipped laboratory, complete agrochemical analyzes of soil samples were performed, which include:

- ✓ determination of soil acidity
- ✓ the specific electrical conductivity
- ✓ mineral nitrogen
- ✓ Assimilate potassium, phosphorus, calcium, magnesium, organic matter (humus), and trace elements.

To achieve the desired result of the project, namely the protection of soil resources, training is provided for farmers, government officials, farmers, businesses, civil society to get acquainted with the basics of ecology and sustainable development of agriculture, to clarify the environmental situation in the region. It includes topics such as: "Atmosphere - air quality, sources of air pollution and the consequences of pollution, pollution control"; "Water - water use and needs, water pollution problems, environmental prospects, water treatment and hazardous waste treatment"; "Solid waste management and soil pollution - waste management and treatment, soil characteristics and protective measures against soil pollution". Sustainable agriculture and waste treatment are key topics for discussion, as the aim is to meet society's current needs for food and textiles without compromising the ability of future generations to meet their own needs.

Sustainable agriculture practitioners seek to integrate three main goals into their work: a healthy environment, economic viability, and social and economic justice. There are many

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practices used by people working in sustainable agriculture and the food industry. Growers can use methods to promote soil health, minimize water use and lower pollution levels on the farm. The forum also aims to conduct practical training for the operation of equipment, for measuring soil quality by a mobile electronic laboratory.

As a leading partner in the project, the Agricultural Chamber – Meric district, Edirne province is implementing the construction of a Center for recycling of plastic boxes, which are a major polluter. As there are 9 000 hectares of rice-growing land in the Meric district area and 2 500 hectares of other agricultural products, the boxes of fertilizers and preparations used by farmers are disposed of in the environment. However, there is a residual amount of chemicals in them. When released into the wild, they leak, and chemical waste contributes to soil pollution. With the construction of a Plastic Box Recycling Center and a laboratory, the problem is expected to be solved.

In the cross-border regions of Bulgaria and Turkey - in Meric district, Edirne province, a study of the state of soil resources and soils will be conducted, as well as training for farmers from the region.

2. General description of the soils in Haskovo region

2.1. Physico-geographical characteristics of the region

Haskovo District is located in the southeastern part of Bulgaria and occupies 5% of the country's territory with an area of 5,543 km^2. The area includes the southwestern part of Sakar Mountain, part of the Eastern Rhodopes and part of the Thracian Lowland. (Figure 1)

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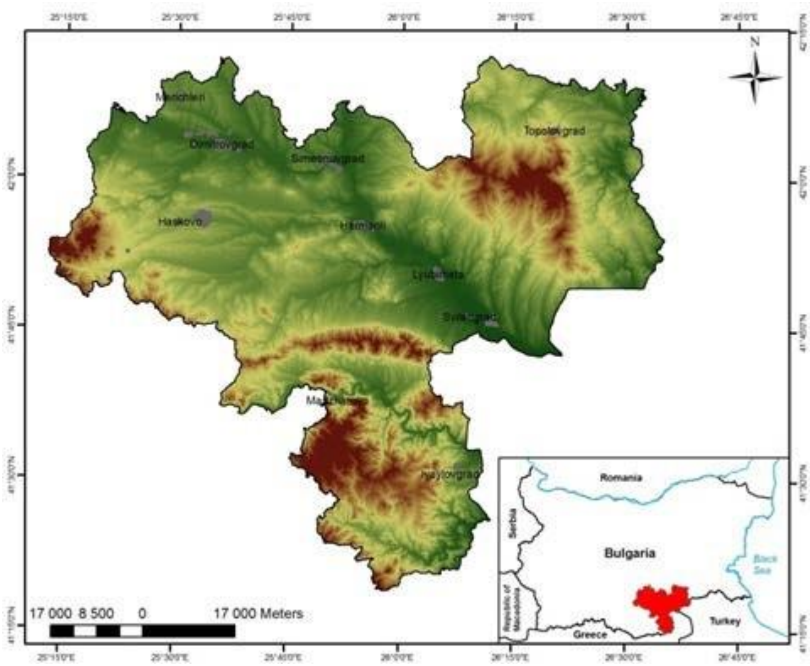

Figure 1. 1. Location of Haskovo region in Bulgaria
Source: Avetisian (2018)

2.1.2. Geological features

In terms of geology and tectonics, most of the Haskovo region is attached to the structures of the Eastern Rhodope block and the Sakaro-Strandzha tectonic zone, which contact with the Marishka fault.

The lithological diversity is represented by pre-Paleozoic and Paleozoic metamorphites and phylitoids, Paleogene volcanic-sedimentary rocks (rhyolites, andesitite, tuffites, tuff-breccias, etc.). The lithological diversity is represented by pre-Paleozoic and Paleozoic metamorphites and phylitoids, Paleogene volcanic-sedimentary rocks (rhyolites, andesitite, tuffites, tuff-breccias, etc.). The Sakar anticline is filled with gneisses, amphibolites, gneiss-shales, metamorphosed granitoids, etc., covered by carbonate sediments. Neogene-Quaternary materials are represented by gravels, sands, clays, coal seams, poorly welded sandstones and core limestones. Ore minerals are associated with lead-zinc, copper-iron, copper-zinc, copper-polymetallic, and non-metallic - with trace, perlite, bentonite, zeolite and others. A small part of the region falls into the Upper Thracian Depression, which is characterized by the presence of conglomerates, sandstones, andesites, tuffs, limestones, alumina, sands, clays, gravels and others (Nam, 2003).

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2.1.3. Relief

The study area is dominated by hilly-ridge and lowland relief, divided by differently configured river valleys, valley extensions and gorges. The horizontal segmentation of the terrain varies from 1.5 to 3.5 km / km^2 and the vertical segmentation is between 50 and 200 m / km^2. About 62% of the territory of Haskovo region is occupied by lands with a slope over 3°. The lands with a slope of 3-9° are 49% of the territory of the region, those with a slope over 9° occupy 2% of the area of the region (Ruseva et al., 2010). As a result of exogenesis, river-valley, volcanogenic and karst landforms have formed (Nam, 2003).

2.1.4. Climate

Haskovo district falls in the Continental-Mediterranean climatic region, characterized by hot summers and mild winters, two maximum rainfall, pronounced summer-autumn drought, episodic and volatile snow cover. (Topliiski, 2006). The average annual temperatures are between 12 °C and 13 °C. The average annual air temperature in the warmest month of July varies between 22.8 °C and 23.7 °C. The average annual air temperature in the coldest month of January is between 0.5 °C and 1.5 °C. The average annual amount of precipitation is about 650 - 700 mm (Topliyski, 2006). The Mediterranean influence affects the amounts and annual distribution of precipitation, which are concentrated mainly in the autumn-winter period and spring and are very limited in summer. Rainfall conditions are intense and torrential in nature to a significant extent which causes floods and intensification of erosion processes, especially in hilly and low-mountainous areas (Velev, 1974). Nearly 14% of heavy rains are erosive. About 12% of the territory of the district, located mainly in the Eastern Rhodopes, is characterized by 4^{th} class rain erosion, and 82% of the territory is characterized by low rain erosion. (Ruseva et al., 2010).

2.1.5. Waters

The largest rivers in the region are Maritsa, Arda and Sazliyka. Surface runoff depends on the rains and snowfalls during the year. The annual distribution of precipitation predetermines the presence of two distinct phases of the river outflow - the phase of high water in April and the phase of low water in September. It is common for smaller rivers to dry up. A typical example is the Byala River, which in the high water phase can generate 60.1 m^3/s, and

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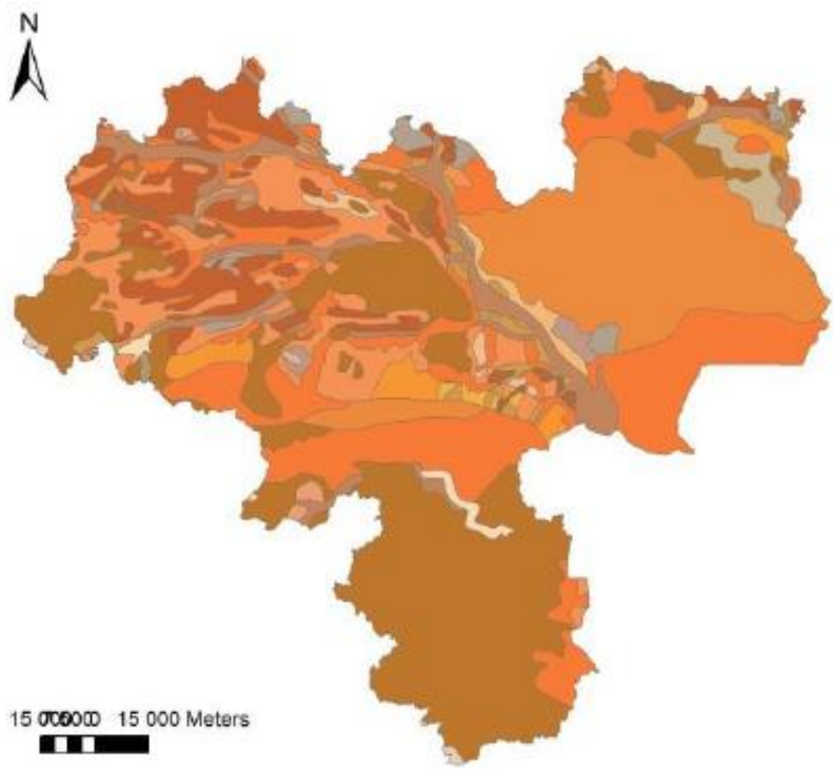
in the low water phase the amount of river runoff is only 1.2 m^3/s. This nature of the outflow is typical for the rivers of the Mediterranean (Nam, 2003; Yordanova, 1972).

2.2. Basic soil types

The territory of Haskovo region falls in the Rhodope-Strandzha province of the South Bulgarian xerothermal soil zone (Koinov et al., 1974). The soil diversity of the area is presented in figure 2. The main soil types in the district are Chromic luvisols, Eroded chromic cambisols, Cambisols, Fluvisols, Mollic fluvisols and Vertisols soils.



Legend

Basic soil types

Chromic luvisols

Eroded chromic cambisols

Cambisols

Fluvisols and Mollic fluvisols

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Vertisols

Figure 2. Main soil types in Haskovo region

Source**:** Avetisian (2018)

2.2.1. Cambisols

Cambisols are the main and most widespread bioclimatic soil type in Central and Southern Bulgaria. They are formed under dry forests and shrubs in Mediterranean, semi-Mediterranean or similar in nature warmer and wetter climates. In fact, cinnamon forest soils in our country are a more northern version of the brown and red-brown Mediterranean soils, which, however, in Bulgaria have a number of specific features due to the transitional Mediterranean conditions. These are more or less clayey, reddish-brown forest soils with well-defined textural differentiation. They occupy the low hilly and foothill areas and the foothills of almost all the mountains in Central Southern Bulgaria. In the valley fields and lowlands they are deep and well developed, formed mainly on Pliocene and Old Quaternary sediments. In the hilly and foothill areas this soils are mostly shallow in a complex with incompletely developed soils formed on various hard rocks.

The area of Cambisols in terms of climate can be generally referred to the transitional-continental area with a Mediterranean climate. Unlike the typical Mediterranean regions, the climate is cooler and wetter, and compared to Northern Bulgaria the winter is warmer. In addition, the area of cambisols is characterized by alternating wet with dry hydrothermal periods - wetter and cooler autumn, milder winter with light rainfall, spring drought with later rainy months and dry and hot summers. The main features and peculiarities of cinnamon forest soils should be sought in the conditions that existed at the beginning of their formation - during the Pliocene and the Old Quaternary, when the formation of most of the chromic cambisols in Bulgaria began.

In the hilly and foothill parts of the country Cambisols are formed on various hard rocks - marble, limestone, marl and sandy limestone, sandstone, granite, rhyolite, diorite, andesite and others. In the valley fields and lowland areas, they are formed mainly on Pliocene and Old Quaternary sediments, which are in fact redeposited weathering and soil products from the upper rocks.

The vegetation under the influence of which the Cambisols were formed in Bulgaria is represented mainly by relatively rare dry forests of the southern hairy oak type, with the participation of cera, winter oak and hornbeam and shrubs from sub-Mediterranean communities.

Both forest and herbaceous vegetation, especially in the fields, have been destroyed in many places and Cambisols are intensively used in agriculture.

They are most typically expressed on old weathering products and deposits in the geochemically accumulative now drained areas and in the softer relief forms.

In general, in the plain regions they occupy genetically the old relief forms, the old terraces and the Pliocene plateaus.

The climatic geomorphological and plant conditions highlighted above indicate of the important and essential role of the time factor, which defines these soils as genetically old, having a heavy mechanical composition and bright reddish coloration. As genetically old, these soils have undergone a long process of soil formation, the manifestation of which is favored by its more intensive course during most of the year and by the alternation of the different wetter hydrothermal periods.

Cambisols, Eroded Choromic cambisols and Chromic luvisols have been identified within the study area.

2.2.2. Choromic cambisols

The leached Choromic cambisols within the boundaries of the studied site are characterized by a medium-strength profile, the depth of which is usually in the range of 1 to 1.6 m moderately and strongly eroded. The thickness of the humus horizon is about 20 - 25 cm. The mechanical composition is quite clayey and depends on the soil-forming rocks and the nature of the relief. The heaviest (slightly to medium clay) soils are formed in the low and flat areas. Lighter (heavy sandy-clayey) are those formed on larger partial materials and on more sloping terrain. A characteristic feature here is the weak differentiation of the clay along the depth of the soil profile. Inside, the soil clay covers the entire profile, but is better expressed in the metamorphic horizon, due to which the amount of clay in it is greater. The clayier is the soil, the greater the participation of montmorillonite in the silt fraction. Red iron hydroxides are also available.

The humus content in these soils under virgin conditions for the humus-accumulative horizon is high 3-4% and gradually decreases downwards. In the case of arable soils in arable land, it has significantly decreased and is on average 2-2.5%. In the presence of carbonates in the arable land, the soils are poorly stocked with comparable forms of iron, zinc, boron and

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manganese, and well stocked with molybdenum, moderately stocked with copper. Leached ones, where the carbonates are relatively deep, are better stored with mobile forms of trace elements. The reaction is neutral in both the humus and metamorphic horizons. CEC (cation exchange capacity) is completely saturated with basic cations (calcium and magnesium). The sorption capacity is relatively high throughout the soil profile 35-50 mequ / 100g soil (for soil profile see Annex 1). Under virgin conditions, these soils have a relatively well-defined structure in the humus-accumulative horizon - water-resistant aggregates larger than 0.25 mm are about 70%. In the arable land, however, the structure is significantly destroyed. Due to the more clayey mechanical composition and the significant destructuring, these soils do not have very good physico-mechanical properties. The plow lyer became sticky when it rains, and when it dries it can form a crust. When cultivate in a drier state, it is crushed into large hard lumps. In the wet state, these soils show great plasticity, stickiness and strongly swell, and when dry they shrink strongly and some of them, like vermisols, crack. Therefore, when cultivate them in both wet and dry conditions, they show a high resistance of 0.7 - 0.9 kg / cm^2. The interval of favorable humidity for cultivation (physical maturity) is short. In accordance with the clay mechanical composition and the values of the main hydrological indicators are high. Thus, the coefficient of wilting varies from 18-24%, and WHC (water holding capacity) 32-34%. The water permeability is too low 0.09 m / 24h. They have an unfavorable water regime. Here the summer droughts are well expressed and a lot of moisture is lost by evaporation from the soil, due to which the cultivation of much later spring crops without irrigation is inefficient. This is especially true for shallower and eroded soils.

2.2.3. Chromic luvisols

The Chromic luvisols within the region are weakly deep, moderately and strongly eroded. The morphology of the soil profile (see annex 1) is typical for the Chromic luvisols in the region. The surface horizon is eluvial bright. Its thickness varies from 0 to about 15-18 cm. The transitional B (t) iluvial-metamorphic horizon is yellow-red in color and has a thickness of 40-70 cm. It has a heavy texture and is significantly compacted. The shallowest profiles of the Chromic luvisols are found in the high convex parts of the terrain, where the soil is very strongly eroded and the illuvial-metamorphic, red-colored transitional horizon is established on the surface.

The structure of the surface horizon is highly diperesed, and in the alluvial-metamorphic horizon it is interspersed with carbonate-free skeletal materials, the granulometry of which is

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characterized by rock fragments with sizes usually in the range of 10 to 50 mm. In the zone of the most active accumulation of clay in the illuvial-metamorphic horizon, the appearance of yellow-red spots of iron oxides is established. The texture of these soils varies depending on the soil-forming materials. The soils formed on Pliocene and Old Quaternary sediments are heavier, and the soils formed on coarser deposited weathering products obtained from granites, granite gneisses and sandstones are significantly lighter. The soils formed on younger river terraces (low valleys) are also relatively lighter in mechanical composition. Shallow soils formed on hard rocks or deposited products thereof have a significantly lighter texture. A sharp profile differentiation is observed along the depth of the profile.

The humus content is generally low, under natural conditions it is 2-3% in the humus-eluvial horizon, and in arable land it has greatly decreased and is about 1%. In more acidic soils (as a result of long-term use of physiologically acidic mineral fertilizers) the quality of humus is even worse (the amount of humic acids is reduced, the participation of the aggressive fraction of fulvic acids and free humic acids is increased, i.e. humus becomes acidic, unsaturated). The reaction in the arable land is usually moderately acidic (pH in water 5-5.5), and in the alluvial horizon below 5. The plow layer of old arable soils is quite highly dusty, water-resistant aggregates are reduced to 30-35%. The deteriorating quality of the humus also reduces the possibilities for structuring. Due to the destructuring and acidification of these soils, they do not have very favorable physical and mechanical properties. In the rain, the plow became sticky and compacted, when it dries, it hardens, a crust is formed and if it is cultivated in such a state, it is crushed into large lumps. The water balance is not very favorable - precipitation is unevenly distributed and due to destructuring much of the moisture evaporates unproductively during the warm dry months.

2.2.4. Eroded Chromic Cambisols

Regarding the susceptibility of these soils to erosion, it was found that 80% of the territory of the region is covered with soils with medium and medium to strong susceptibility to erosion; 6% - from soils with strong susceptibility to erosion and 10% - from soils with very weak and low susceptibility to erosion. (Ruseva et al., 2010). Soils with strong susceptibility to erosion are concentrated in the foothills of the Eastern Rhodopes and Sakar, at the transition to the Upper Thracian Lowland.

Erosion changes the morphological and hence the physico-chemical properties of soils. Thus, the carbonates in the Eroded chromic cambisols are washed at an average depth between

70 and 130 cm. The thickness of the humus horizon varies widely between 5 and 35 cm. The thickness of the compacted horizon compared to the non-eroded ones can be reduced to zero or covers the soil layer between 0 and 120 cm. In addition, the compacted horizon due to the humus horizon is mostly started from the surface itself.

2.2.5. Vertisols

These are heavy textured soils, forming in the summer wide cracks with a depth of up to 50 cm from the surface. Vertisols contain more than 60% physical clay. They occupy the plains and are often in a complex with Cambisols. They have a "gilgay" relief. It is characteristic for them that they have wavy contact with the soil-forming materials and are mulched on the surface (Boyadzhiev, 1994a, b).

Despite the not very high content of organic matter in Vertisols (about 3.5% evenly distributed on the profile) the color of these soils is usually dark, often black, which is related to the quality of this very well evolved organic matter. The minerals montmorillonite in these soils are often mixed with a small amount of silt and represent 40 to 60% of the total soil mass, determining the physico-chemical properties of the profile. The cation exchange capacity is usually very high - 40 to 80 meq / 100 g. This is due to the predominance of montmorillonite.

The essential characteristic of Vertisols is their homogeneity, associated with constant stirring through circular motions. The differentiation is very weak - 80 to 100 cm. In some cases, when less evolved organic matter is abundant, a structure coarser than that of the rest of the profile is formed on the surface. In summer, small clay aggregates are formed, which form surface mulch, protecting the lower part of the profile from drying out. Horizon B is characterized by the presence of cracks that are more or less wide and distinguish large prisms.

According to the classification of soils adopted in Bulgaria, soils with circular motions are separated into a separate type - vertisols, and four subtypes are defined - carbonate, typical, leached. The most widespread are the leached resins (Atanasov, 1987).

In the soil classification of the international organization FAO Vertisols are divided into a separate category of the highest order and are divided into two groups - Pellic Vertilols (dark colored) and Chromic Vertisols (light colored).

The thickness of the soils in the region of Haskovo exceeds 2 m. The soil is characterized by a very heavy texture, the clay varies from 56.9 to 65.7%, unfavorable general physical

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properties (bulk density 1.38 to 1.45 g / cm^3, low porosity - less than 50%), a small amount of air (6.9 to 12.0%), large water capacity and good to satisfactory water drainage.

These soils are rich in organic matter. The amount of humus in the humus-accumulating horizon is 2.9 to 4.5%, they contain a large amount of alkaline hydrolyzable nitrogen, a sufficient amount of available forms of phosphorus, potassium and iron.

The carbonates in the soil are washed to a depth of less than 60 cm and do not exceed 6-7%. The reaction of the soil is from neutral to slightly alkaline.

The data indicate that these soils have a very good water capacity (WHC is from 24.7 to 28.0%), which is important for a number of crops that can be grown without irrigation.

The exchangeable cations (calcium Ca^{2+} and magnesium Mg^{2+}) and the absorbed iron are sufficient for the normal rate of chlorophyll photosynthesis in plants.

The heavy texture of the vertisols determines their unfavorable physical and mechanical properties - high plasticity, stickiness and bonding in the wet state and high hardness in the dry state. Therefore, they are difficult to be cultivated. They have high resistance during cultivation. The texture also determines high values of the main hydrological indicators - high WHC (water holding capacity) 36-38%, high percentage of wilting humidity 20-25%, due to which from 60 to 65% of the water supply is dead (unavailable water).

Despite some not very favorable properties, vertisols also have very good qualities that create great potential for high fertility of these soils.

2.2.6. Fluvisols

Fluvisols soils are referred to as river sediments (alluvium) or alluvial-meadow soils. In the FAO international soil classification, the name Fluvisols is adopted, which means river soils. Occupy parts of the flood terrace (arch) of the larger rivers. They are located on both sides of the riverbed. These soils are very young. They are in the early stages of development.

Contemporary soils in the area are formed on powerful sediments of Neogene-clays, sands, incompletely weathered sandstones, with high quartz content. In some places, in the northeastern parts of the terrains, infiltration limestones have been established, in a complex with marls and calcareous conglomerates and alluvial sediments on the high terraces of the Maritsa River. The Maritsa alluvial deposits are mainly the Quaternary terraces, and in the studied area they are mainly of sandy-clay composition. The underlying base of the Maritsa terraces is represented exclusively by alternating layers of Pliocene gravel, sand and clay. Due to the differences in the temporal nature of sediment erosion, caused mainly by changes in the

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bed of the Maritsa River, the water saturation of the indicated Pliocene deposits is not the same. The maximum water content in the region is manifested in the areas close to the Maritsa River, near the eroded waterproof deposits, in contact with the Maritsa terrace deposits.

These soils have not formed genetic horizons, but there are only separate layers or the primary humus horizon (A) is barely outlined, followed by different layers of sediments - most often sandy. From the upper flow of the river to its estuary, the sediments become finer.
As the riverbed moves away to the first non-flooding terrace in the area of the middle part of the arch, the water moves more slowly when the river overflows and deposits smaller particles. This creates conditions for sustainable development of meadow vegetation and the transition of alluvial soils to alluvial-meadow. In the farthest part of the riverbed near the non-flooded terrace the finest materials are rarely deposited. The terrain is the lowest (groundwater is close to the surface). Meadow-swamp and swamp vegetation develops well here and the soils turn into meadow-swamp and peat-swamp. When the terrace remains high and the soils are no longer flooded, they gradually turn into the zonal soils typical of the area.

The farther these soils are from the riverbed and closer to the estuary, thir texture is heavier. In terms of profile depth, the soil texture is also very heterogeneous. The soils are sandy to sandy-clayey in dept. The humus content is low 1-2%. The physico-chemical properties of these soils depend on the content of carbonates and clay. In carbonate soils the reaction is slightly alkaline, and in others it is neutral to slightly acidic. In the case of intensive fertilization of weakly acid soils with physiologically acidic nitrogen fertilizers, there is a danger of their further acidification. Fluvisols have good physical and mechanical properties, they are loose, do not sticky and crack, do not form crusts. They can be lightly cultivated at any time. In terms of water properties, they are characterized by good water permeability, but not high moisture content.

Fluvisols have good natural fertility and are used intensively in agriculture. Many agricultural crops are successfully grown on the more widespread clayey-sandy and sandy-clayey Fluvisols - cereals, legumes, all major vegetable crops, vineyards and fruit species. Areas with shalow groundwater can be used as meadows.

2.2.7. Mollic Fluvisols

Mollic Fluvisols are similar to the Fluvisols described above. They differ in that they are further away from the riverbed, due to which the sediments are finer in part, the groundwater is closer to surfase (about 1.5 m). They are flooded infrequently and for a short time, during

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which very fine sediments are deposited. This allows the development of moisture-loving meadow vegetation from cereals and legumes grasses and sedges, under the influence of which a well-defined humus horizon is formed. The grassy vegetation here is considered to be secondary. The primary vegetation was moisture-loving forest - field ashl, elm, willow, poplar and others. Now it is largely destroyed and the soils are cultivated or used as meadows. The soils are young, representing the next stage in the development of Mollic Fluvisols. Soil formation is characterized by accumulation of mature humus. The conditions for the formation of humus are favorable. Here the meadow vegetation develops well and the large amount of plant residues (mainly as roots) is intensively humified, many humic acids are formed. They bind to calcium and remain in the soil as calcium humate. Depending on the change of the hydrological regime of the territory, when the level of the groundwater approaches the surface, they pass into meadow-swamps. When the level of the groundwater decreases, they gradually pass into the zonal soils for the region. Their texture is heavier than the Fluvisols ones. They are medium sandy-clayey. They are layered and finer in depth. The humus content in virgin soils is 2-4%, and in arable 1-2%.

2.3. Factors influencing soil degradation processes

In recent decades, there has been a tendency to increase the adverse effects on soils in Bulgaria, which cause their degradation. Degradation is defined as damage or destruction that adversely affects one or more soil functions. Eight threats have been identified that cause soil degradation: erosion, acidification, salinization, compaction, reduction of soil organic matter, pollution, sealing and landslide development. There is a tendency to increase soil erosion, decrease soil organic matter and the area of disturbed soils.

2.3.1. Soil erosion

Soil erosion is associated with the release and transport on the surface of the soil of soil particles by water or wind, which causes loss of soil material from the surface horizons of the soil, and with it the loss of organic matter and nutrients. This has an adverse effect on the crops grown, causing a reduction in their yields. Erosion removed as a result of erosion can block local infrastructure and drainage system, cause losses to owners, pollute water sources and destroy plant and animal habitats. The intensity of water erosion is determined by many factors, but one of the main ones is the application of agricultural systems that accelerate erosion processes.

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The loss of vegetation leads to erosion processes, which in turn lead to loss of soil fertility, causing further deterioration and reduction of vegetation. The model is an example of a common manifestation of the processes associated with land degradation. This type of interaction indicates the influence of the stabilizing role of vegetation as a factor protecting soils from the occurrence and development of erosion processes.

The problem of land degradation is the most common and is most pronounced in land used for agricultural purposes. In areas with a dry climate, poor agricultural practices, combined with natural conditions and the intensification of drought are among the leading factors causing the formation of erosion processes and land degradation.

Photo 1. Intensive erosion process

The average annual soil erosion losses can vary from insignificant to several hundred tons/ha/year. More than 50% of the country's soil cover is moderately, severely and very severely affected by water erosion. According to Lazarov and Nekova (2005), the annual loss of soil material through surface and jet water erosion of arable land is estimated at 216 033 300 tons (average 7.2 t / ha), but for 10.4% of the country's potential risk exceeds 100 tons / ha /

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year. The total loss of the main nutrients (nitrogen, phosphorus and potassium) through surface erosion from agricultural land is estimated at 74 million euros / year.

Wind erosion takes place on plain areas and deforested areas. According to some estimates (Russeva and Stefanova, 2005), wind-sensitive soils in Bulgaria, which can lose up to 50 tons / ha / year of soil material, occupy about 85% of the country's territory.

2.3.2. Measures to prevent soil erosion

Planting vegetation as ground cover is the best method again soil erosion. Farmers can plant trees and grass to cover and bind the soil. Plants prevent wind and water erosion by covering the soil and binding the soil with their roots. The best choice of plants to prevent soil erosion are herbs, wild flowers and small trees.

There are several basic methods to prevent soil erosion in agricultural lands, which are applied depending on the slope of the terrain.

Agrotechnical measures

Anti-erosion crop rotations

In land management, it is necessary to provide for the long side of the fields to be in the direction of the horizontals for areas endangered by water erosion and transverse to the prevailing winds for areas endangered by wind erosion.

Anti-erosion crop rotations include a larger number of crops which cover entire surface of the field (wheat, barley, rye, triticale oats, rapeseed, etc.), as well as perennial grasses and mixtures thereof. When raw crops are included, the crop rotation fields must be narrower and arranged in the form of belts in the horizontal direction. In this way, raw crop belts alternate on the slope with crop belts with crops which cover entire surface to cross the water outflow.

The sowing of grass belts between the separate fields of the crop rotation by perennial grass species parallel to the horizontals of the field significantly reduces the water erosion.

Preferably winter crops, as well as cover crops and green manure crops between the main crops, should be included in the crop rotation. As a result, the fields are in a state of black fallow for a shorter period of time.

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Photo 2. Belt cultivation of crops

Source: https://www.worldatlas.com/articles/what-is-contour-farming.html

Application of appropriate soil tillage

• The direction of tillage should be on the long side of the fields, i.e. horizontally or across to prevailing winds.

• Uneven plowing (on furrows and ridges) is preferable. If necessary, make deeper furrows to retain and drain excess water. The furrowing is expressed in passing furrows on the surface of the plowed soil parallel to the horizontal furrows, 25 to 30 cm deep, at a distance of 1.5-2 m watering. By drilling the furrows, a wavy surface is obtained, which retains the surface runoff much more efficiently and facilitates the infiltration of water into the soil.

• Tillage should be done perpendicular to the slope or horizontally, the so-called contour tillage. These methods are applied on terrains with a slight slope.

• For perennials, space between raws can be strengthened by sowing of grasses (partial or complete) or sown / planted with other crops, and / or tillage can be carried out perpendicular to the slope or horizontally.

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Photo 3. Grassing between rows in perennials

Application of the appropriate sowing direction

Sowing should be done along the fields, across the slope.

Anti-erosion grassing

Anti-erosion grassing is applied on areas with a large slope - from 10 to 15 °. Belts of perennial grass fodder are sown every 50-100 m to restrict surface runoff. Other crops are sown between them. The belts are in the direction of the horizontals, perpendicular to the slope.

The width of the grass strips is 6-8 m, and the distance between them varies from 20 to 80 m. The width of the strips and the distance between them are determined by the length and slope of the slope, the anti-erosion resistance of the soil, the type of cultivated crops. Grassing is done with suitable perennial grasses or mixtures of them. Grass buffer strips have a high anti-erosion and environmental effect. They retain a large part of the surface runoff formed above them. At the same time, they provide a good refuge for some species of wild animals and birds during the periods when the area is free of vegetation or various technological operations are carried out such as plowing, fertilizing and spraying with herbicides, hoeing, harvesting and others.

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Mulching

Mulching also has a positive effect on reducing soil erosion. In this managment practice, the soil is covered with various plant residues - straw, stalks of corn, sunflower, tobacco, cotton and others. Straw after the harvest of winter cereals can be cut into small peacies and left on the soil surface as mulch.

The soil protective action of mulch is expressed in several ways: it protects the soil from the destructive action of raindrops; reduces surface water runoff and increases the absorption of water into the soil, protects it from evaporation and helps to preserve the organic matter in it.

Forest reclamation activities

These activities include the construction of various forest plantations from trees and shrubs in the form of belts. The construction of anti-erosion belts is an expensive activity. It takes some time to show its effectiveness. The largest investment in Bulgaria in this direction was made in the 50s of the 20th century, when a field protection belt was built in the region of Dobrudzha.

• In case of danger of water erosion of the soil, water-regulating forest belts must be built - in the direction of the horizontals, perpendicular to the slope, which will absorb the surface water runoff and reduce the force of the water flow;

• In case of danger of wind erosion of the soil, wind protection forest belts must be built - across the direction of the prevailing winds, which will reduce the wind speed in the ground layer of air.

Hydrotechnical measures

The main hydrotechnical mesure is the terracing of the slopes. It eliminates or significantly reduces water runoff and soil removal on the slope.

Two types of terraces can be build:

• Bank terraces: They are built on small slopes, have a wide base, small height and sloping slopes. This allows mechanization to be used and field crops to be sown. Bank terraces are built with a slope of the terrain not exceeding 15%.

• Stepped terraces: They are built on steeper slopes, have a narrower base and are used mainly for growing perennials.

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Photo 4. Stepped terraces

2.3.3. Reduction of soil organic matter (SOM)

There are no systematic observations of the state of soil organic matter (POM) in the soils of Bulgaria, but some research data, summarized recently in a separate thematic collection, indicate that the total stock of organic carbon in them amounts to 1.3 Gt (Filcheva, 2014). There is a clear tendency to reduce the content of SOM in arable land. The reduction of the content of SOM in the arable layer of the arable lands, in comparison with the uncultivated soils varies between 10 and 40%. (Filcheva, 2005; Artinova, 2014). This is due to the intensive cultivation, the burning of the post-harvest residues, the limited use of organic fertilizers. The removal of the surface soil layer as a result of water erosion also contributes to the reduction of soil organic matter. According to estimates, the area of soils in Bulgaria with humus content in the surface layer <1% occupies 490,000 ha, and the area of soils with SOM content between 1 and 2.5% occupies an area of about 3.7 million ha. For comparison, the area of arable land in the country is less than 5 million ha.

2.3.4. Soil acidification

According to estimates, about 9.8% of soils in the country have a pH (H_2O) level <5.0 (Atanassov, 2012). Approximately 500,000 ha of acidic soils under cultivation have an acidity level that is unfavorable for some sensitive crops. The strong acidity of soils is largely associated with long-term application of unbalanced fertilization and the use of mineral fertilizers that increase soil acidity. Soil acidification is also registered as a result of SO_2 emissions into the atmosphere, which enter the soil with rainwater in the form of sulfuric acid, as well as the deposition of acidic industrial waste, which is localized entirely around point sources. There are no data to assess the trend of changes in soil acidity for Bulgaria. Estimates

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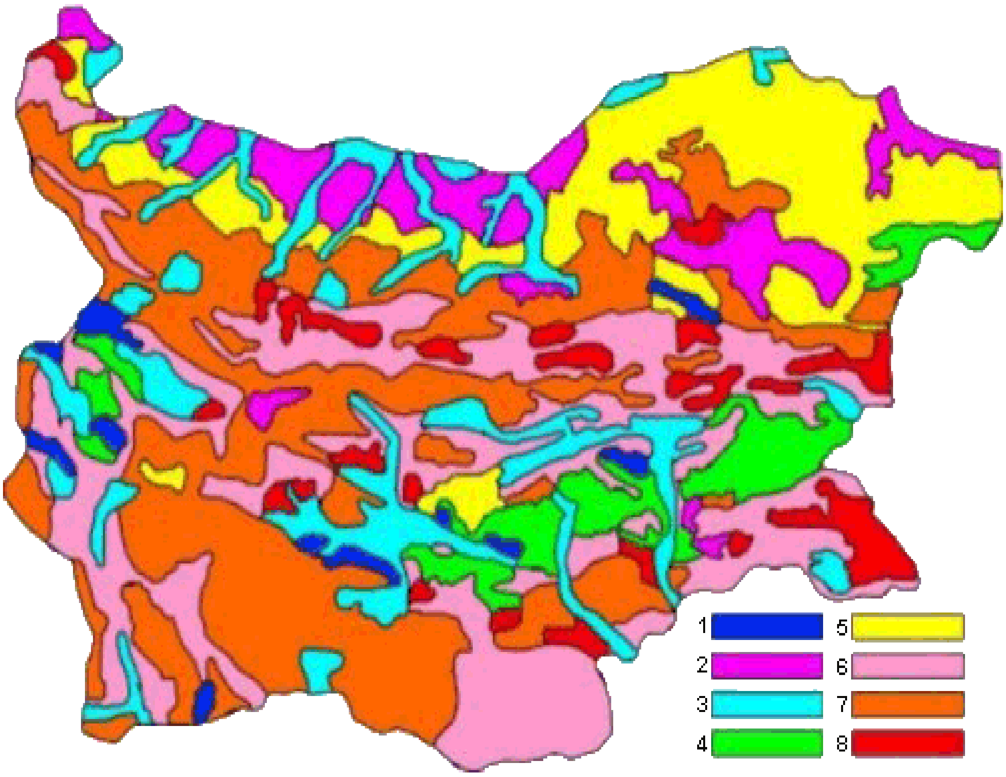
relating to the EU (Jones et. Al., 2012) indicate a tendency to reduce acidification. This is explained by measures to reduce SO_2 emissions from industrial enterprises and coal-fired power plants, and by the application of fertilization schemes that limit the use of physiologically acidic mineral fertilizers.



Legend

1 - alkaline; 2 – slightly alkaline; 3 - slightly alkaline to neutral; 4 - neutral;
5 – neutal to slightly acid; 6 – slightly acid; 7 – medium acid; 8 - strongly acid

Figure 3. Soil reaction in Bulgaria

2.3.5. Soil salinization

The saline and alkaline soils occupy 35.5 thousand ha in Bulgaria and are located mainly in lower and poorly drained places in the Thracian lowlands, in terraces along the Danube and in

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some sections along the Black Sea coast. These soils belong to the soil types of solonchaks and solonetz. They are all the product of natural salinization processes. Saline soils formed as a result of anthropogenic impacts cover an area of approximately 250 ha (Todorova, 2002) and are the result of incidents around industrial enterprises or the use of salt water for irrigation. There is no clear tendency to increase or decrease the area of saline lands.

Photo 5. Naturally saline area in Belozem, Plovdiv region

2.3.6. Soil compaction

This soil degradation can be defined as a process of unfavorable increase in the bulk density of the soil accompanied by a decrease in its porosity and water permeability. Possible reasons for soil compaction are: wet soil cultivation, excessive traffic, use of heavy agricultural machinery, re-plowing at the same depth, trampling by passing animals, poor soil structure, and low organic matter content.

Various indicators can be used to assess soil compaction, such as soil bulk density, penetration resistance, porosity, root depth distribution. Among them, the bulk density is the most easily feasible and complex. Kercheva and Dilkova (2005) offer reference optimal, critical

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and limit values for bulk density, taking into account soil aeration, soil texture and content of SOM (soil organic matter). Limit values for bulk densities of 1,85, 1,6 and 1,35 g / cm^3 are determined for soils with coarse, medium and clay texture of horizon A or the arable soil horizon, respectively. Volume density values of 1.7-1.8 g / cm^3 are typical for a plow heel. Unacceptably high values of bulk density can be obtained by repeatedly passing machines on the soil surface when fertilizers, pesticides or other treatments are applied, especially when the soil is moist.

Photo 6. Soil compaction by heavy machinery

2.3.7. Soil pollution

A coordinated system for inventory of soil pollution has been established in Bulgaria, which works on the basis of approved standards and a system for assessment of the degree of pollution. It includes a range of heavy metals, arsenic, radionuclides, persistent organic pollutants (POPs), pesticides and petroleum products. According to monitoring data (Todorova, 2003), the area of soils in Bulgaria contaminated with various chemicals and radionuclides is estimated as follows:

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-	Lands contaminated with heavy metals and arsenic	43 600 ha;
-	Lands contaminated with radionuclides	1 049 ha;
-	Lands contaminated with petroleum products and pesticides	137 ha;
-	Other (including POPs) approx	100 ha;
	Total	44 896 ha.

Soils contaminated with heavy metals and arsenic are more or less well studied and mapped. The pollution is the result of point sources and the contaminated sites are located in the vicinity of ferrous and non-ferrous metallurgical enterprises, along highways or near chemical enterprises. In most cases, contaminated soils contain a mixture of heavy metals. Among the most common pollutants are lead, copper, zinc, cadmium. Some soils are contaminated with arsenic.

Bulgarian soils are also polluted by the introduction of a number of chemicals to control diseases, pests and weeds in cultivated plants (fungicides, insecticides and herbicides) commonly called pesticides. These preparations decompose after a while and become harmless. Used in large quantities, they can accumulate in soil and plants and adversely affect animal and human health.

3. Survey - a survey among farmers

The study of soils in the Haskovo district was conducted within the framework the project "Save nature to save the future" co-financed by the European Union through the Cross-border Cooperation Program INTERREG - IPA Bulgaria - Turkey 2014 - 2020, in which partners are the Chamber of Agriculture in the Turkish town of Meric and the employers' organization CEIBG Haskovo.

The laboratory equipment planned for the project for analysis of soil samples has already been delivered and put into operation in Haskovo. It helps farmers in the area who receive on-site the results of the survey of the soils they use. The farmers participating in the project acquire skills to correctly take and deliver the samples for analysis. These samples determine the pH indicators of the soil, humus content, ammonium and nitrate nitrogen content, digestible phosphorus content and digestible potassium content. Based on these indicators, they can, based on developed rules and norms for fertilization of the main groups of crops with mineral and

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organic fertilizers to optimize the nutrients in the soil to obtain higher yields and minimize the risk of soil, water and soil pollution. environment.

3.1. Structure of the carried study

The first 42 soil samples were supplied by ten farmers cultivated in the study in eleven villages in the Haskovo region. The sample includes one agricultural production cooperative, one joint stock company, two sole proprietorships with limited liability, two sole traders and four registered agricultural producers. They differ in the size of the arable land, the structure of the cultivated crops and the applied agricultural practices.

Table 1: Structure of the surveyed farms

Farms	Land /ha/	Villages	Plots
“Agro-pioner” JSC	200	2	7
“Eskalibur” Ltd.	50	1	4
ST “Boyan Geokov”	680	1	10
ST “Mihail Srebrev”	200	1	2
RAP “Jelyazko Jelyazov”	15	1	3
RAP “Lubka Hristozova”	700	1	4
RAP “Nayden Naydenov”	20	1	3
RAP “Tencho Iliev”	200	1	2
APC Mariyno	500	1	4
„Yani Agro - 85“ Ltd.	440	1	3
TOTAL for the survey	3 005	11	42

Source: Data from the soil survey

To establish the attitude of farmers to the soils they use, they were asked nine questions directly related to their farm. The answers allow to get an idea of the way of land use, the type and quality of some of the used agricultural practices and to make some, though not completely representative conclusions.

- ✓ What are the main cultivated crops, pastures, and meadows?

The structure of the cultivated crops is extremely poor, with wheat and sunflower present on all ten farms. The maximum number is of four crops, which allows a better balance between the use of labor and other factors of production.

- ✓ What are the main kept animals by species and numbers?

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The farmers included in the sample deny the breeding of animals, which is not a traditional characteristic of the Bulgarian village. It is also surprising that two of the farms grow alfalfa, and one manages 25 hectares of meadows.

- ✓ What crop rotations are applied and are they applied?

The crop rotations used on the farms are most often with two crops, which is determined both by the structure of the cultivated crops and the underestimation of this production practice.

- ✓ What types and quantities of fertilizers are used in different types of crops?

In the monitored agricultural holdings in the Haskovo region, only mineral fertilizers are used, even in the presence of greenhouse areas. This is determined by the lack of animals in them and does not allow to maintain the level of organic matter in the soil even during its intensive use.

Mostly combined (two and three component mineral fertilizers) and ammonium nitrate are used, which does not always correspond to the needs of the plants.

- ✓ How are diseases and pests controlled, what pesticides are used?

The effective use of integrated plant protection practices is a key criterion for assessing modern farms. It turns out that this is beyond the power of producers in the field. The limited range of pesticides they use, most often supplied with sunflower seeds, could not ensure a successful fight against diseases and pests, and especially weeds.

- ✓ How and where are these pesticides stored?

Timely delivery and proper use and storage of pesticides are the main factors in reducing the risk of their use in agriculture. Of the ten farms included in the study, they have the capacity to store them. The rest rely on the possibility of delivery at the time of use, which is not always appropriate.

- ✓ What to do with old or surplus pesticides? Is this a potentially serious soil contaminant?

The interviewed farmers do not acknowledge the presence of old or redundant pesticides and problems with them. Against the background of the increased number of cases with pesticides at risk for the soil and the way of their delivery and use, this fact is not unambiguous.

- ✓ How is household waste collected in the villages and towns around the border? Is there an organized system for collection and disposal, possibly waste treatment?

The system for collection and disposal of household waste in the Haskovo region and specifically in the monitored villages is well developed. This is confirmed by all farmers included in the survey.

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✓ Are there any measures in place to combat soil erosion?

In interviews with farmers, they claim that they do not apply agricultural practices or other measures to combat soil erosion. This could be explained by the lack of a significant slope of the plots included in the soil survey.

Photo 7: Farmers take soil samples
Source: website http://agropal-bg.com/

3.2. Conclusions from the study

Although it does not claim to be representative of the region, the surveys conducted with ten farmers from the Haskovo region give grounds to draw the following important conclusions:

- The main crops grown in the area are wheat and sunflower
- The breeding of animals on farms is very limited
- The main applied crop rotation is two-plots
- The number of fertilizers used is insufficient, most often using combined mineral fertilizers and ammonium nitrate
- The set of pesticides used does not comply with the requirements of agricultural crops and integrated plant protection
- Storage of pesticides is risky because only two of the farmers have suitable warehouses for them
- Agricultural producers deny the existence of old and dangerous pesticides

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- The current system for waste collection and disposal is efficient without guaranteeing their safe liquidation
- Farmers underestimate the problem of water erosion in the agricultural plots

4. Soil analysis - results of chemical analysis of soil samples

`Results from the analysis of soil samples from municipalities in Haskovo district were made as a result of the work on the project № CB005.2.12.112 "Save nature to save the future", contract № РД-02-29-252 / 04.10.19, funded by the Interreg-IPA Bulgaria-Turkey Cross-Border Cooperation Program 2014-2020, co-financed by the Instrument for Pre-Accession Assistance II of the European Union.

The soil samples taken from the agricultural lands were carried out in laboratory conditions in compliance with the technological requirements. For this purpose, equipment delivered within the project was used.

In the frame of the project 42 soil samples from different fields in Haskovo district were analyzed for the content of the main nutrients - nitrogen, phosphorus and potassium. In addition to the content of available macronutrients in the soil, another important soil indicator of direct importance for plant development was measured - the soil reaction (pH).

Table 2. Soil analyses of samples from the territory of Svilengrad municipality

№ of	**village**	**place**	**Soil reaction pH_{KCl}**	**Nitrogen mg N / kg (N)**	**phosphorus mg P_2O_5 / 100 g**	**Potassium mg K_2O /100 g**

sample						
1	v. Shtit	Chardaka	**7,2**	**9,9**	**0,4**	**17,7**
2	v. Shtit	Germelika	**7,5**	**10**	**0,2**	**22,3**
3	v. Shtit	Solana	**7,2**	**8,1**	**0,1**	**15,0**
4	v. Kapitan Andreevo	Chital tepe	**7,0**	**27,9**	**0,3**	**22,5**
5	v. Kapitan Andreevo	two hills	**7,1**	**16,6**	**0,3**	**38,7**
6	v. Kapitan Andreevo	Chengene dere	**7,1**	**16,7**	**5,1**	**56,1**
7	v. Kapitan Andreevo	Lesna dere	**6,3**	**13,7**	**5,1**	**24,6**
8	v. Kapitan Andreevo	Yurd dere 2	**5,5**	**13,9**	**2,6**	**29,1**
9	v. Kapitan Andreevo	Chalyr hill	**4,8**	**14,4**	**2,3**	**12,6**

Table 3. Soil analyses of samples from the territory of Mineralni bani municipality

№ of sample	**village**	**place**	**Soil reaction pH_{KCl}**	**Nitrogen mg N / kg (N)**	**phosphorus mg P_2O_5 / 100 g**	**Potassium mg K_2O /100 g**
1	v. Tatarevo	Karsheka	**4,0**	**20,5**	**4,5**	**27,0**
2	v. Tatarevo	Kajryaka	**5,5**	**30,7**	**11,9**	**26,1**
3	v. Tatarevo	Pamuklucite	**4,9**	**81,7**	**3,4**	**23,4**

Table 4. Soil analyses of samples from the territory of Dimitrivgrad municipality

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№ of sample	village	place	Soil reaction pH_{KCl}	Nitrogen mg N / kg (N)	phosphorus mg P_2O_5 / 100 g	Potassium mg K_2O /100 g
1	v. Raynovo	Karacheir	5,3	14,7	11,2	28,2
2	v. Raynovo	Goliam Karalan	7,0	14,0	0,4	18,2
3	v. Raynovo	Ismenova koriya	7,1	27,3	0,3	27,3
4	v. Raynovo	Bunardzik	7,0	14,6	21,1	20,4
5	Dimitrovgrad	Chukata	6,9	26,0	4,4	18,3
6	Dimitrovgrad	Chuchkite	6,9	17,9	3,5	17,1
7	Dimitrovgrad	Shirok kar	6,6	39,3	15,9	24,6
8	Dimitrovgrad	Goren Bozalak	6,8	14,9	3,3	29,1
9	v. Dolno Belevo	Parchetata	6,0	27,1	8,4	11,7
10	v. Dolno Belevo	Dyuz Orman	6,0	11,5	10,1	20,4
11	v. Dolno Belevo	Bozuka	6,5	12,9	1,9	18,6
12	v. Dolno Belevo	Botica	6,6	30,3	12,4	28,8
13	v. Skobelevo	Furazni parceli 1	6,8	7,8	24,6	1,7
14	v. Skobelevo	Chomurluka	6,9	24,9	14,1	45,9
15	v. Skobelevo	Furazni parceli 2	4,9	36,9	4,3	20,7
16	v. Radievo	Kosharite ugar	5,6	27,5	5,4	15,3
17	v. Radievo	Chatala	6,4	14,4	0,1	15,6
18	v. Radievo	Giola-rapseed	5,6	18,8	3,7	24,3
19	v. Radievo	Giola-rapseed	4,9	20,2	2,0	21,0
20	v. Radievo	Giola	5,9	28,2	3,6	23,7
21	v. Radievo	Goliam blok	6,9	32,1	3,3	21,9
22	v. Radievo	Sarba dere	6,5	23,4	1,3	19,5
23	v. Radievo	Grobeto	6,9	16,8	2,0	22,8
24	v. Radievo	Diado Kanyovia blok	6,8	23,6	1,8	18,9
25	v. Krepost	Katla dere	5,5	45,9	0,5	1,5
26	v. Krepost	Barbite	7,0	25,6	0,3	1,2
27	v. Stalevo	greenhouses	5,9	44,7	44,7	40,2
28	v. Stalevo	Kavak dere	6,6	74,2	15,5	61,5
29	v. Stalevo	Byukya	5,6	8,1	12,1	70,2

Legend

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(for the stock of the soil with the various nutrients)

Soil reaktion (pH)	
strongly acidic	< 5,5
acidic	5,5 – 6,0
slightly acidic	6,0 – 7,0
neutral	araund 7,0
slightly alkaline	7,0 – 8,0
alkaline	8,0 – 8,5
strongly alkaline	> 8,5

Nitrogen mg N / kg (N)	
very low content	< 20 mg
low content	21 – 40 mg
average content	41 – 60 mg
good content	61- 80 mg
very good content	> 81 mg

Phosphorus mg P_2O_5 / 100 g	
very low content	< 3 mg
low content	3 – 6 mg
average content	6 – 12 mg
good content	12- 20 mg
very good content	> 20 mg

Potassium mg K_2O /100 g	
very low content	< 8 mg
low content	8 – 12 mg
average content	12 – 18 mg
good content	18 - 30 mg
very good content	> 30 mg

Analysis of the obtained results

The assessment of the soil reaction in the studied plots expresses their low total acidity. It could be explained by the recent and more distant history of their use. There are some concerns about only some of the minimum values that raise the question of the efficiency of agriculture in these plots.

The results of determination the soil acidity of the analyzed soil samples indicate that the three samples from the land of the village of Tatarevo are characterized by a strongly acid reaction (Table 3). One of the samples taken in the villages of Radievo, Skobelevo, Raynovo and Kapitan Andreevo also showed a strongly acid reaction (Tables 2 and 4). Another seven soil samples in the villages of Radievo, Krepost and Kapitan Andreevo have an acid reaction. In both groups of fields with strongly acid and acid reaction, the introduction of physiologically acidic fertilizers in the cultivated crops should be avoided. Of the nitrogen fertilizers, the most suitable for use is calcium ammonium nitrate (CAN). The calcium content of this fertilizer neutralizes the acidity of the soil caused by the use of ammonium nitrate.

Soils which reaction is in the range between slightly acidic and slightly alkaline are suitable for growing all crops. They can use all types of fertilizers without the above-mentioned (CAN).

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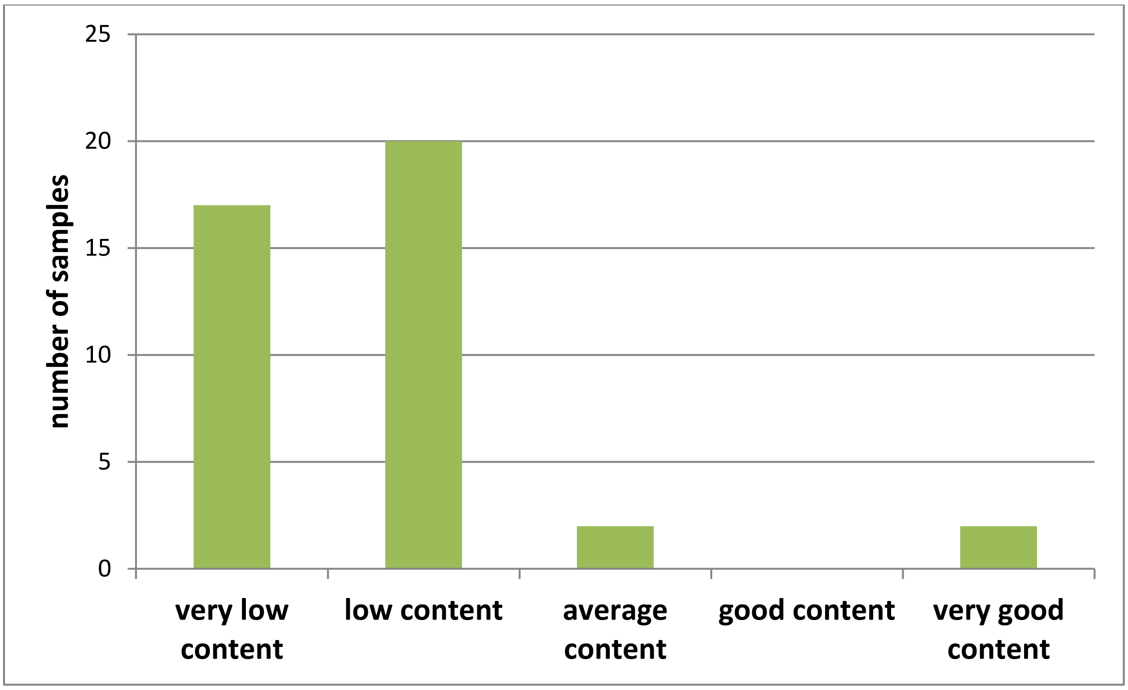

Figure 3. Distribution of samples depending on the soil's nitrogen content

The stock of soils with available nitrogen in most of the tested samples can be characterized as very low content or low content (figure 3). This group includes 37 samples. This is not surprising because nitrogen is an element that is very mobile in the soil and its reserves are depleted relatively quickly. This is the reason to practice the splitting of the nitrogen fertilizer rate, one part of which is applied before sowing / transplanting the crop, and the rest is applied as one or more fertilizers doses during the growing season (see point 5.2.).

Only two soil samples show an average content of nitrogen and two are with very good content - one is in the village of Stalevo for growing cucumbers, and the other is in the village of Tatarevo on land with field crops.

The average levels of soil nitrogen supply are relatively low and despite the high mobility of this element it would be difficult to provide the necessary (40-60 mg / kg) for plant development quantities. The variation of nitrogen stocks between individual plots is quite high, which can be related to the approach of farmers and the diversity of agricultural practices used by them.

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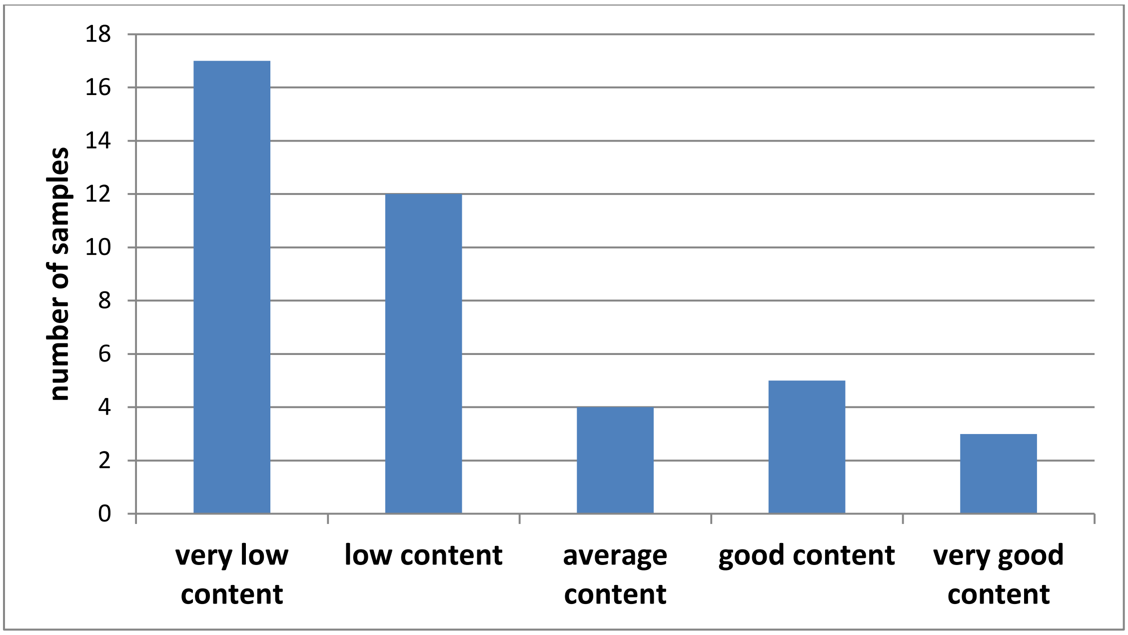

Figure 4. Distribution of samples depending on the soil's phosphorus content

Unlike nitrogen, phosphorus is characterized by very low mobility in the soil. The analysis of the results of the soil samples indicates that the vast majority of them have a very low or low content of available phosphorus for the plants (28 samples) (figure 4). With significant fluctuations in values, due to differences in soil types, there are samples that indicate a lack of fertilization with phosphorus fertilizers in recent years. When determining the fertilizing rates for these fields, the rates for the phosphorus fertilizers used should be increased. In eight of the samples, the stock of mobile phosphorus was good or very good. Accordingly, the phosphorus fertilizer rates for the next growing season must be reduced or completely excluded from fertilization scheme.

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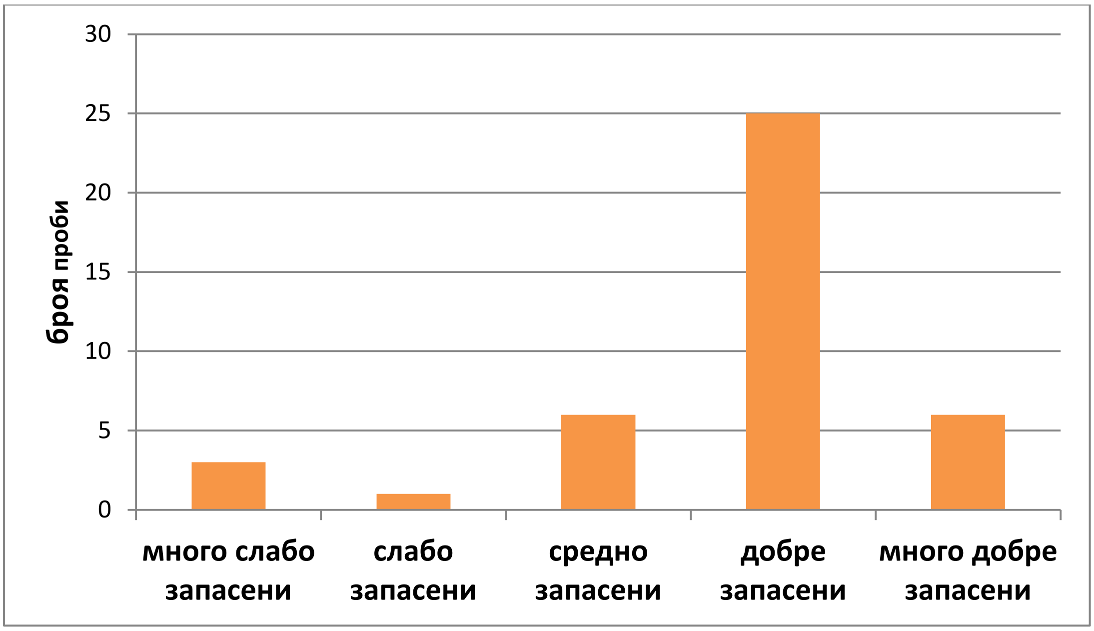

Figure 5. Distribution of samples depending on the soil's potassium content

The analysis of the levels of soil supply with potassium confirms long-known characteristics of the Bulgarian soils that they are well stocked with available potassium for the grown crops. Of concern are some minimum values that threaten the cultivation of some potassium-loving crops.

In contrast to phosphorus, only four of the soil samples can be characterized by very low or low content of available potassium (Figure 5). In general, most Bulgarian soils are characterized by a naturally high content of the nutrient.

In thirty-one of the samples, the soils are well stocked or very well stocked with potassium. Due to this very high stock of the element in some years, fertilization with the potassium fertilizers can be excluded, but this should not be a long practice (several consecutive years), because the stocks will gradually run out and yields will be reduced.

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Description of the places where soil samples were taken

Community	villafe	place	The way of permanent use	Plantation at the time of the study	Crop rotation	Applied fertilizers	Used pesticides, herbicides, insecticides, fungicides	Visualization at the time of the study
Dimitrovgrad	Skobelevo	Chomurluka	field	fallow	Two years crop rotation	DAP	Vaztak	
Dimitrovgrad	Skobelevo	Fodder plots	field	wheat	Two years crop rotation	DAP, AN, UREA	„Aksial“ „Tabgo super“	

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Community	villafe	place	The way of permanent use	Plantation at the time of the study	Crop rotation	Applied fertilizers	Used pesticides, herbicides, insecticides, fungicides	Visualization at the time of the study
Dimitrovgrad	Stalevo	Byukya	field	wheat	Two years crop rotation	NPK	Aksial	
Dimitrovgrad	Stalevo	Kavak dere	field	fallow	Two years crop rotation	NPK	-	
Dimitrovgrad	Stalevo	Stalevo	field	cucumber	Two years crop rotation	NPK, AN, Калиев нитрат	Mospilan Videyt Verita	

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Community	villafe	place	The way of permanent use	Plantation at the time of the study	Crop rotation	Applied fertilizers	Used pesticides, herbicides, insecticides, fungicides	Visualization at the time of the study
Dimitrovgrad	Dolno Belevo	The pieces	field	rapeseed	Two years crop rotation	NP, AN	Uish top Aksial	
Dimitrovgrad	Dolno Belevo	Dyuz Orman	field	Plowed field	Two years crop rotation	AN	-	
Dimitrovgrad	Dolno Belevo	Bozuka	field	sunflower	Two years crop rotation	AN	Maza 4SL Policar +	

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Dimitrovgrad	Dolno Belevo	Botica	field	Plowed field	Two years crop rotation	AN	-	
Community	**villafe**	**place**	**The way of permanent use**	**Plantation at the time of the study**	**Crop rotation**	**Applied fertilizers**	**Used pesticides, herbicides, insecticides,**	**Visualization at the time of the study**
Dimitrovgrad	Raynovo	Big Karalan	field	fallow	Two years crop rotation	DAP, AN	-	
Dimitrovgrad	Zlato pole	Bunardzik	field	fallow	Two years crop rotation	NP, AN	-	
Dimitrovgrad	Zlato pole	Kara chair	field	fallow	Two years crop rotation	DAP, AN	-	

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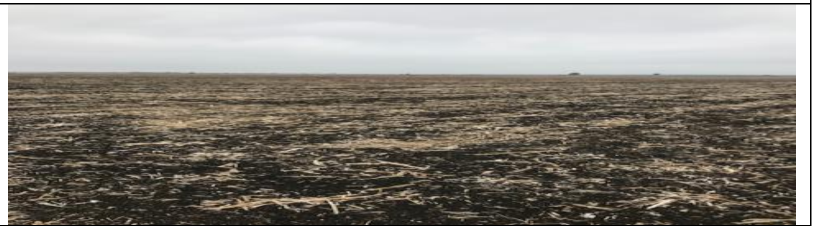
Dimitrovgrad	Raynovo	Ismenova kyria	field	fallow	Two years crop rotation	NP, AN	-	

Community	**villafe**	**place**	**The way of permanent use**	**Plantation at the time of the study**	**Crop rotation**	**Applied fertilizers**	**Used pesticides, herbicides, insecticides, fungicides**	**Visualization at the time of the study**
Dimitrovgrad	Dimitrovgrad	Chukata	field	fallow	Two years crop rotation	TSP, AN	-	
Dimitrovgrad	Dimitrovgrad	Vast kar	field	fallow	Two years crop rotation	DAP, AN	-	

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Dimitrovgrad	Dimitrovgrad	Goren bozalak	field	fallow	Two years crop rotation	NPK, AN	-	
Dimitrovgrad	Dimitrovgrad	Chukite	field	fallow	Two years crop rotation	AN	-	

Community	**villafe**	**place**	**The way of permanent use**	**Plantation at the time of the study**	**Crop rotation**	**Applied fertilizers**	**Used pesticides, herbicides, insecticides,**	**Visualization at the time of the study**
Svilengrad	Shtit	Solana	field	Plowed	Two years crop rotation	DAP, AN	-	
Svilengrad	Shtit	Chardaka	field	Plowed	Two years crop rotation	DAP, AN	-	

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Svilengrad	Shtit	Garmelika	field	Plowed	Two years crop rotation	AN	-	

Community	**villafe**	**place**	**The way of permanent use**	**Plantation at the time of the study**	**Crop rotation**	**Applied fertilizers**	**Used pesticides, herbicides, insecticides, fungicides**	**Visualization at the time of the study**
Dimitrovgrad	Radievo	Kosharite	field	wheat	Two years crop rotation	TSP, AN	Aksial Derby super Mustang	

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Dimitrovgrad	Radievo	Gyola	field	rapeseed	Two years crop rotation	AN	Grandstar super Aksial Mustang	
Dimitrovgrad	Radievo	The big block	field	Plowed	Two years crop rotation	AN	Derbi super Aksial	

Community	**villafe**	**place**	**The way of permanent use**	**Plantation at the time of the study**	**Crop rotation**	**Applied fertilizers**	**Used pesticides, herbicides, insecticides, fungicides**	**Visualization at the time of the study**

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Svilengrad	Generalovo	Chadar hill	field	rapeseed	Two years crop rotation	NP, AN	Uish top	
Svilengrad	Generalovo	Yurt dere 2	field	wheat	Two years crop rotation	NP, AN	Aksial Derbi super Mustang Pulsar	
Svilengrad	Generalovo	Chengene dere	field	wheat	Two years crop rotation	NP, AN	Aksial Derbi super Mustang Pulsar	

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Community	**villafe**	**place**	**The way of permanent use**	**Plantation at the time of the study**	**Crop rotation**	**Applied fertilizers**	**Used pesticides, herbicides, insecticides, fungicides**	**Visualization at the time of the study**
Svilengrad	Kapitan Andreevo	Chital tepe	field	wheat	Two years crop rotation	NP, AN	Aksial Derbi super Mustang Pulsar	
Svilengrad	Kapitan Andreevo	Two hils	field	wheat	Two years crop rotation	NP, AN	Aksial Derbi super Mustang Pulsar	
Svilengrad	Kapitan Andreevo	Chengene dere	field	wheat	Two years crop rotation	NP, AN	Aksial Derbi super Mustang Pulsar	

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Community	**villafe**	**place**	**The way of permanent use**	**Plantation at the time of the study**	**Crop rotation**	**Applied fertilizers**	**Used pesticides, herbicides, insecticides, fungicides**	**Visualization at the time of the study**
Mineralni bani	Tatarevo	Kajryaka	field	wheat	Two years crop rotation	DAP	Aksial	
Mineralni bani	Tatarevo	Kyrsheka	field	wheat	Two years crop rotation	DAP	Aksial	
Mineralni bani	Tatarevo	Pamuklucite	field	stubble	Two years crop rotation	-	-	

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Community	villafe	place	The way of permanent use	Plantation at the time of the study	Crop rotation	Applied fertilizers	Used pesticides, herbicides, insecticides, fungicides	Visualization at the time of the study
Dimitrovgrad	Krepost	Katla dere	field	fallow	Two years crop rotation	TSP	-	
Dimitrovgrad	Krepest	Varbite	field	fallow	Two years crop rotation	TSP	-	

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Community	villafe	place	The way of permanent use	Plantation at the time of the study	Crop rotation	Applied fertilizers	Used pesticides, herbicides, insecticides,	Visualization at the time of the study
Dimitrovgrad	Zlato pole	Bunardzik	field	fallow	Two years crop rotation	NP, AN	-	
Dimitrovgrad	Zlato pole	Kara chair	field	fallow	Two years crop rotation	DAP, AN	-	

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5. Rules and rates for fertilization of the main groups of crops

5.1 Plant nutrients and deficiency symptoms

Plants absorb about 7 percent of the elements that make up their tissues from the soil. The remaining 97% is absorbed by air (carbon and oxygen) and water (hydrogen). These three elements are called non-mineral. Through the process of photosynthesis, plants use solar energy to bind CO_2 from the air (source of carbon and oxygen) and water (source of hydrogen and oxygen) to synthesize carbohydrates.

Mineral nutrients are absorbed by the soil and are conditionally divided into two groups - macronutrients, which are found in quantities greater than 0.01% by weight of plant dry matter and micronutrients, the amount of which is less than 0.01 %. The first group includes the elements nitrogen, phosphorus, potassium, calcium, magnesium and sulfur, and the second - iron, manganese, zinc, copper, boron and molybdenum.

Nitrogen, phosphorus and potassium are absorbed in the largest amounts by the soil, which is why these elements often need to be fertilized. These three elements are called primary.

Calcium, magnesium and sulfur are the next three elements in amounts of absorption. In Bulgarian soils, especially those with a neutral and alkaline reaction, their quantity is sufficient for plant development and fertilization with these elements is less frequent. They are called secondary.

Microelements are absorbed by plants in very small quantities, but they are vital and in the absence of any of them the plants cannot complete their life cycle. The presence of absorbable forms of micronutrients in plants in the soil largely depends on its reaction. In acidic soils, the amount of available iron, manganese, zinc and copper increases. Therefore, crops grown on acidic soils can very rarely be deficient in these elements. In alkaline soils, however, their content decreases, which makes it necessary to use fertilizers containing these trace elements. The content of boron and molybdenum increases in alkaline soils and vice versa decreases in acidic ones. In neutral soils with a pH of about 7, the amount of all micronutrients is sufficient for crop growth.

5.1.1. Nitrogen (N)

Nitrogen is the most important nutrient for plants. It is absorbed in the largest amounts by the soil and is contained in all living cells. Nitrogen is an integral part of the molecules of proteins, enzymes, nucleic acids and others. It is part of chlorophyll - the green pigment responsible for photosynthesis. Nitrogen has a strong effect on growth and improves the quality of seeds and fruits.

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Nitrogen deficiency symptoms

In case of element deficiency, disturbances in the formation of chlorophyll occur (photo 1). Yellowing of leaves called chlorosis is observed. Plants are characterized by slow growth and generally remain smaller in size. Characteristically, the signs of deficiency (chlorosis) initially appear on the lower, oldest leaves. This is because nitrogen can be reused in the plant. When the soil cannot provide enough nitrogen for the young growing parts of the plant, it moves nitrogen from the old leaves to the younger.

Photo 8. Nitrogen deficiency symptoms in corn

5.1.2. Phosphirus (P)

It is the second most important nutrient. It affects the formation and development of roots and growth of young plants. The phosphorus improves the ripening of fruits and seeds.

Phosphorus deficiency symptoms

The symptoms of a phosphorus deficiency are very specific and can hardly be mistaken for another element deficiency. They are characterized by the appearance of bluish, purple, reddish spots and / or streaks mainly on the periphery of the leaves, which remain small and at the base of the stems in cereals (photo 2). As with nitrogen, the lower, oldest leaves are initially affected.

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Photo 9. Phosphorus deficiency symptoms in corn (left) and barley (right)

5.1.3. Potassium (K)

Potassium is absorbed by plants in amounts close to those of nitrogen. It is necessary for the budding of flowers, as well as for the process of photosynthesis - to fix the carbon dioxide converted by the plant into starch and sugars. Potassium affects the movement of these organic compounds from leaves to seeds, fruits and vegetables. For this reason, potassium has a strong positive effect on product quality.

Potassium deficiency symptoms

Symptoms on the leaves begin to appear from older to younger. Chlorotic spots appear, which necrotize rapidly, concentrated mainly on the periphery of the leaves. Gradually, the affected organs and tissues die. Fruits and vegetables from plants grown in potassium deficiency are few in number, small, deformed, with atypical coloring, unsuitable for canning, spoil quickly during transportation and storage (photos 3 and 4). Cereal seeds have low absolute weight and low germination. Particularly sensitive to potassium deficiency are vegetable crops and potassium-loving crops (potatoes, most vegetable crops, berry crops - strawberries, raspberries, etc., fodder - alfalfa, clover, annual legumes, oilseeds - sunflower, canola, etc.). Cereals are less sensitive to element deficiency.

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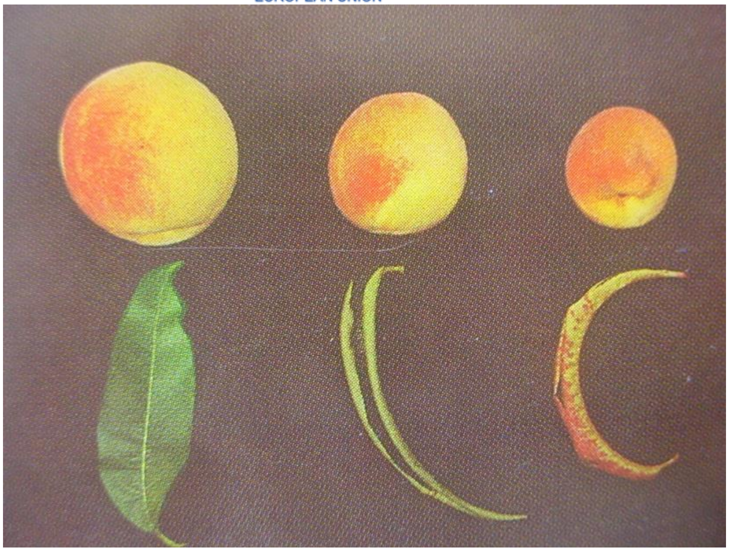

Photo 10. From left to right, good supply of peach with potassium, less shortage and very strong shortage

Photo 11. Potassium deficiency in wheat (left) and corn (right)

5.1.4. Sulfur (S)

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Sulfur is important for normal growth and for normal, well-functioning green leaves. It is important for the efficient absorption of nitrogen. Sulfur is needed for the synthesis of some essential amino acids (cysteine and methionine, which are not synthesized in the human body, but must be taken with food) and proteins.

Although S is not a component of chlorophyll, it is still vital for chlorophyll formation. Sulfur affects fat synthesis and is therefore important for oilseeds. Improves root growth. Sulfur forms complex compounds with aluminum and reduces its toxicity to plants in acidic soils.

Sulfur deficiency symptoms

Sulfur deficiency occurs on younger leaves, which become light green to yellowish. The symptoms are similar to nitrogen deficiency. The formation of tubers on the roots of legumes is reduced. Sulfur-deficient plants are small and slow to grow. The symptoms can vary from plant to plant. For example, in maize, sulfur deficiency manifests as interstitial chlorosis; in wheat the whole plant becomes pale, while the younger leaves are more chlorotic; in the case of potatoes, pale spots may appear on the leaves. Leaf symptoms resemble nitrogen deficiency, especially when both elements are deficient. In case of sulfur deficiency, both old and young leaves turn yellow.

Photo 12. Sulfur deficiency in wheat (left) and corn (right)

5.1.6. Magnesium (Mg)

Magnesium is a component of chlorophyll, which determines its important role in the process of photosynthesis. Participates in the activation of plant enzymes that affect plant growth. Its deficiency depends on the amount of potassium in the soil. As excess potassium decreases, magnesium becomes available. The lack of magnesium is evident in the yellowing between the leave’s veins.

Magnesium deficiency symptoms

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In case of deficiency, disorders in the synthesis of chlorophyll begin. It concentrates around the leaf nerves and the tissues between them turn yellow. The leaves become variegated as a result of fading between the veins. Of the crops, Mg deficiency is most common in corn, potatoes, sugar beets, alfalfa and flax. Initially, the oldest leaves are affected - interveinal chlorosis appears.

Photo 13. Magnesium deficiency in beans

5.1.7. Calcium (Ca)

The main function of calcium is its participation in the construction of cell walls. It is responsible for cell growth in the plant body. Calcium is also involved in the development of leaves and roots of plants.

Calcium deficiency symptoms

Signs of deficiency appear on the tops of the plants as the new leaves are crooked and irregularly shaped. The tips of the young leaves curl downwards and their periphery curves towards the upper or lower surface. In case of calcium deficiency, tomato fruits are affected by peak rot, this disease is less common in peppers and aubergines.

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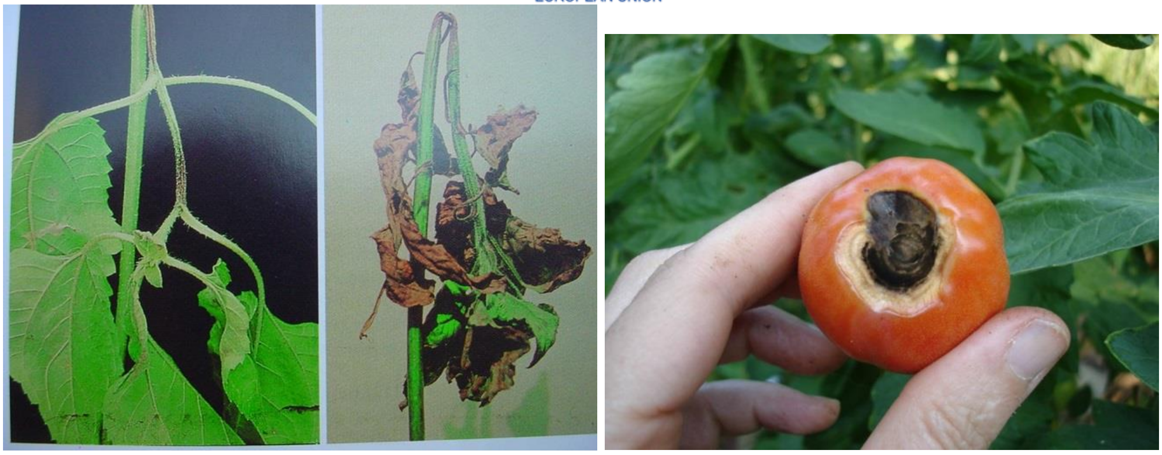

Photo 14. Calcium deficiency in sunflower (left) and peak rot of tomatoes (right)

5.1.8. Iron (Fe)

Iron strongly affects the synthesis of chlorophyll. It is a component of some enzymes and proteins. Iron regulates the respiration of the plant cell.

Iron deficiency symptoms

Iron deficiency appears in the form of chlorosis (yellowing of young leaves, only their veins remain green). A light yellow color appears between the veins of the leaves. With more severe chlorosis, the entire leaf becomes creamy white, dotted with large necrotic spots. Gradually the tops of the shoots dry out, individual branches or whole trees die. The young leaves on the tops are affected. The most sensitive crops to iron deficiency are fruit, vines, roses and others.

Photo 15. Iron deficiency in vineyards (left) and apples (right)

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5.1.9. Boron (B)

Boron plays an essential role in the development of flower organs, seeds and fruits. Participates in the synthesis of sugars. Helps use and regulate other nutrients. In its absence, symptoms similar to calcium deficiency appear.

Boron deficiency symptoms

First of all, the growth points are affected, the vegetation top of the stem dies, the formation of new organs stops. The leaves turn yellow, then darken and their stalks become brittle. Lack of boron during the flowering period disrupts the normal development of pollen, due to which most of the flowers remain unfertilized and fall off.

Photo 16. Initial signs of boron deficiency in beets (left), corn cob with reduced number and deformed grains as a result of boron deficiency

5.1.10. Copper (Cu)

Copper is needed to stabilize chlorophyll. The element affects the growth and division of cells, as well as to stimulate enzyme activity. Copper is also needed for nitrogen and carbohydrate metabolism. Its deficiency causes white plague in cereals and drying of the tops of the shoots of fruit trees. Its deficiency leads to a bluish tinge to the young leaves.

Copper deficiency symptoms

In cereals, the leaf tips turn white and dry quickly, twist into strands and warp.

In fruit trees, the growth of the apical leaves slows down, their edges curl upwards, chlorosis appears (on a light green background, a network of dark green veins stands out). The withered leaves fall off and the top of the shoot is exposed.

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Photo 17. White plague on cereals caused by a shortage of copper

5.1.11. Zinc (Zn)

Zinc is an element that plays an essential role in the synthesis and transformation of carbohydrates. It is part of the enzyme systems that regulate growth. Zinc is important for energy and protein metabolism, the formation of vitamin C and B. It affects pollination.

Zinc deficiency symptoms

In case of element deficiency, growth retardation and almost complete cessation of internode growth is observed. Between the veins of the leaves from the base to the top appear wide and narrow light green, yellowish-white stripes. Corn is particularly sensitive to zinc deficiency.

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Photo 18. Symptoms of zinc deficiency in corn

5.1.12. Molybdenum (Mo)

Molybdenum plays an essential role in the absorption of atmospheric nitrogen. Molybdenum is important for the activity of many enzymes in the cereal plants, especially those related to nitrogen metabolism. It also participates in the synthesis of phytohormones. At deficiency, the leaves are covered with yellow spots. Molybdenum deficiency reduces the number and size of male and female flowers in corn. Reduces the chlorophyll content in corn and yield. The internodes of corn are shortened, the leaf area is reduced and chlorosis appears on the leaves.

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Photo 19. Symptoms of molibdenium deficiency in corn

5.2. Main terms for application of fertilizers

When fertilizing agricultural crops, three main terms of fertilizer application are used.

1. Basic fertilization, which is carried out before the main tillage (deep plowing) and provides nutrients for the entire growing season. Fertilizers are imported in layers at greater depths, which increases their availability and mineralization. Suitable for basic fertilization are organic fertilizers, and phosphorus and potassium fertilizers from industrial, as well as some fertilizers containing trace elements (low-percentage ores, industrial waste, etc.).

2. Pre-sowing (sowing) fertilization is carried out with pre-sowing tillage and the fertilizers are plowed at the depth of sowing. It aims to provide nutrients for the initial periods of plant development, and in some cases for the entire growing season (eg. phosphorus and potassium in cereals with a fused surface). Suitable for pre-sowing fertilization are slow-acting nitrogen fertilizers, synthetic urea and ammonium sulfate, as well as ammonium nitrate and a number of microfertilizers (water-soluble salts, chelates).

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3. Application during vegetation - provides nutrients during certain phases of crop vegetation. Nitrogen fertilizers (ammonium, sodium, calcium nitrate) and microfertilizers (water-soluble salts and chelates) are used.

These main fertilization terms are not mandatory for all crops, but are used differently in accordance with the biological requirements and characteristics of the plants, soil, climatic and other growing conditions.

5.3. Methods of fertilizer application

There are two ways of applying fertilizers - spread and locally (belt).

- Spread application: the fertilizer is spread evenly over the entire soil surface. This method is suitable for crops with a fused surface such as cereals.
- Local or belt application: fertilizers are applied only on a part of the area near the crop rows. Depending on the technology of growing crops, this method has several varieties:
  - Nesting - fertilizers are introduced into the planting hole when planting fruit, vines or sowing watermelons, melons, pumpkins.
  - Furrow - fertilizers are imported at a certain width near the rows of crops.
  - raised beds - fertilizers are imported only in the beds of cultivated vegetable or flower crops.

Recently, a third method of fertilizer application is increasingly used, along with irrigation water in drip irrigation systems, or so-called fertigation.

5.4. Basic mineral fertilizers

Nitrogen fertilizers

Ammonium nitrate (ammonium nitrate) - contains 33.5-34.4% nitrogen in ammonium and nitrate form. The fertilizer is suitable for all soils and crops. It can be used both for pre-sowing fertilization and for application during the growing season.

Stabilized ammonium nitrate - contains at least 31.5% nitrogen in ammonium and nitrate form and stabilizing addition of phosphorus - 1-4% P_2O_5. It is suitable for pre-sowing fertilization.

Calcium-ammonium nitrate - is a mixture of ammonium nitrate and ground limestone. It contains at least 20% nitrogen in ammonium and nitrate form and 20% carbonates. It is suitable for fertilizing acidic soils to reduce harmful soil acidity. It should not be used on carbonate soils.

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Urea - contains 46.0-46.3% nitrogen in amide form. It is suitable for pre-sowing fertilization on all soils, except for soils with alkaline reaction. To avoid possible nitrogen losses from volatilization, it is important to incorporate the fertilizer into the soil immediately.

Ammonium sulfate - contains 20.5-21.0% nitrogen in ammonium form. Physiologically acidic fertilizer, therefore not recommended for soils with acid reaction. It is most suitable for soils with high calcium content.

Sodium nitrate (Chilean nitrate) - contains 15-16% nitrogen in nitrate form. Physiologically alkaline fertilizer and can be applied to soils with acid reaction. Sodium degrades the physical properties of soils by displacing calcium from the soil uptake complex and should therefore not be used frequently.

Phosphorus fertilizers

Modern phosphorus fertilizers differ in chemical composition and solubility. Due to the low mobility of phosphorus, it is recommended that its application with fertilizers be with appropriate tillage to the depth of the main root mass.

Triple superphosphate - concentrated, granular phosphorus fertilizer, contains 46% P_2O_5. It is suitable for all soils and crops.

Precipitate - contains 30-40% P_2O_5. Recommended for acidic soils due to the comparatevely low solubility of the fertilizer.

Phosphoric flour - **tricalcium phosphate,** contains 12-20% P_2O_5. Recommended for acidic soils due to the difficult solubility of phosphorites.

Potassium fertilizers

All potassium fertilizers are water soluble, which makes them easily available for plants. Potassium fertilizers are of two main types - potassium chloride and chlorine-free potassium fertilizers - potassium sulfate and other derivatives thereof. Both types are suitable for all soils, and the choice of the form of potassium fertilizer should be made depending on the crop to which it is applied. There are crops that do not tolerate chlorine and they must be applied chlorine-free form of fertilizer.

Potassium chloride - contains 60% K_2O. It is suitable for all soils and crops that are not sensitive to chlorine.

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Potassium sulfate - contains 50% K_2O and 18% sulfur. It is suitable for all crops that are sensitive to chlorine. An important advantage is the presence of sulfur in the fertilizer, which is also an important nutrient

Patentkali - contains 30% K_2O, 10% MgO and 17% sulfur. All elements are in water-soluble form and are suitable for all soils.

Multi-element fertilizers

Amophos (MAP) - ammonium phosphate, contains 12% N and 60% P_2O_5. It is suitable for pre-sowing fertilization, especially of autumn cereals, where the needs for nitrogen in the fall are lower. Well soluble fertilizer, which makes it suitable for fertigation.

Diamophos (DAP) - diammonium phosphate, contains 20-21% N and 51-53% P_2O_5. It is applied as Amophos.

Potassium nitrate (potassium nitrate - contains 13.5% N and 46.5% K_2O. It is suitable for pre - sowing fertilization, especially of autumn cereals, for feeding and for greenhouse production.

The content of nutrients in each fertilizer is less than 100%, because each element is part of a chemical molecule. The difference between the % of the nutrient and up to 100% is occupied by the other atoms that make up the corresponding molecule. The fertilizer rates presented in the tables below and the rates given as recommendations by chemical laboratories are presented in active substance, ie. how many kilograms of pure nitrogen, for example, should be imported in order to satisfy the crop needs. To recalculate how many kilograms of physical substance from a fertilizer corresponds to the recommended fertilizer rate given in an active substance, Table 5 can be used.

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Table 5. Conversion of the active substance into physical depending on the percentage content in the mineral fertilizer

Active substance in the fertilizer	Kilograms per hectare in physical substance depending on the fertilization rate (kg/ha)												
	20	30	40	50	60	70	80	100	120	140	160	180	200
10%	200	300	400	500	600	700	800	1000	1200	1400	1600	1800	2000
12%	160	250	333	417	500	583	667	833	1000	1167	1333	1500	1667
14%	143	214	286	357	429	500	571	714	857	1000	1143	1286	1429
15%	133	200	267	333	400	467	533	667	800	933	1067	1200	1333
16%	125	188	250	313	375	438	500	625	750	875	1000	1125	1250
17%	118	176	235	294	353	412	471	588	706	824	941	1059	1176
18%	111	167	222	278	333	389	444	556	660	778	889	1000	1111
20%	100	150	200	250	300	350	400	500	600	700	800	900	1000
22%	91	136	182	227	273	318	364	455	543	636	727	818	909
26%	77	115	154	192	231	269	308	385	462	538	615	692	769
27%	74	111	148	185	222	259	296	370	444	519	593	667	741
28%	71	107	143	179	214	250	286	357	429	500	571	643	714
30%	67	100	133	167	200	233	267	333	400	467	533	600	667
32%	63	94	125	156	188	219	250	313	375	480	500	563	625
34%	59	88	118	147	176	206	235	294	353	412	471	529	588
40%	50	75	100	125	150	175	200	250	300	350	400	450	500
42%	48	71	95	119	143	167	190	238	286	333	381	429	476
46%	43	65	87	109	130	152	174	217	261	304	348	391	435
48%	42	63	83	104	125	146	167	208	250	292	333	375	417
50%	40	60	80	100	120	140	160	200	240	280	320	360	400
52%	38	58	77	96	115	135	154	192	231	269	308	346	385
60%	33	50	67	83	100	117	133	167	200	233	267	300	333
75%	27	40	53	67	80	93	107	133	160	187	213	240	267

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Examples:

1. If we are going to use a fertilizer with a nutrient content of 34% (ammonium nitrate) and the recommended rate is 80 kg in active substance, in the corresponding column we find the amount in physical substance of the fertilizer - in this case 235 kg.
2. If we are going to use a fertilizer with a nutrient content of 46% (triple superphosphate) and the recommended norm is 120 kg in active substance, in the corresponding column we find the amount in physical substance of the fertilizer - in this case 261 kg.

5.5. Rules and rates for fertilizing field crops

In winter field crops with a fused surface (crops which cover the entire surfice of the field – cereals, etc.), the entire phosphorus and potassium fertilizer rate is imported before sowing in the fall.

Nitrogen is applied separately - one third of the total nitrogen rate is imported before sowing, and the remaining 2/3 - in the spring. Suitable fertilizers for pre-sowing fertilization are urea and ammonium fertilizers plus ammonium nitrate, ie. fertilizers containing nitrogen in the form of ammonium. Ammonium nitrogen is less mobile in the soil, which is why its application before sowing reduces the loss of the element from leaching in the lower soil layers. Fertilizers containing nitrogen in nitrate form, such as ammonium nitrate, are suitable for application during the growing period of the crop. Nitrates are very mobile in the soil and become available to plants immediately after their introduction into the soil.

As nitrogen is a nutrient that most strongly influences the growth of crops, its need is greatest in periods of rapid growth. These are the period of tillering and stem elongation in cereals and phase 7 - 12 leaves of maize development. That is why the higher nitrogen doses are applied at these stages of development of cereals. During these periods of development, plants absorb the biggest quantities nitrogen.

Nitrogen fertilization in spring should not be delayed due to the risk of drought and to use the available soil moisture and nitrogen. Very early application of nitrogen (as early as January) can be done only on flat places and with heavier soils that are not easily washed away by water (chernozems, vertisols, etc.).

On light and shallower soils, and on sloping terrains, fertilization of crops should be done later, in late February and early March. On sloping terrains, the nitrogen rate in the spring should be given

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twice to limit the washing of the fertilizer. For the same reason, nitrogen fertilizers are not spread on thick snow and on very frozen soil.

When fertilizing with high levels of nitrogen, the crops of winter cereals suffer - the drought resistance of the plants decreases, and with more moisture and stormy time before ripening, the crops fall (lodging of crops). With abundant nitrogen fertilization, autumn plants are attacked by more diseases and pests.

Phosphorus favors the germination of seeds, as well as the formation of generative organs of winter crops. Potassium increases resistance to low temperatures, fungal diseases and lodging. Potassium activates enzymes that support nitrogen metabolism. In this way the content of total protein and gluten is increased, which improves the quality of the obtained grain. Potassium increases drought resistant of crops.

Mineral nutrition of winter cereals

Winter cereals grow best on neutral, slightly alkaline or slightly acidic soils. Rye and especially triticale tolerate soil acidification more easily than wheat and barley.

Mineral nutrition of wheat

The provision of wheat with mineral nutrients throughout the growing season ensures high yields and quality production. Intensive varieties are characterized by higher requirements for nutrients and can fully realize their genetic potential only with a full and balanced supply of nutrients. Wheat exports a significant amount of nutrients from the soil along with the harvest.

Soft wheat

To form a yield of 100 kg of grain, the followingamounts of nutrient should be absorbed: 2.5 - 3.5 kg of nitrogen; 1.1 - 1.3 kg of phosphorus; 2.0 - 2.7 kg of potassium; 0.5 kg of calcium; 0.4 kg of magnesium; 0.35 kg of sulfur; 0.5 g of boron; 0.85 g of copper; 0.270 g of iron; 0.82 g of manganese; 0.60 g zinc; 0.07 g molybdenum. There is a dependence that the higher the yield and the higher the rate of mineral fertilization, the greater the export of nutrients.

Durum wheat

For the formation of 100 kg of grain at fertilization levels from 60 to 180 kg N / ha durum wheat absorbs 30.5 – 43.7 kg N, 12 - 15 kg P_2O_5 and 17 - 24 kg K_2O. Nitrogen fertilization increases grain yield by 29.0 - 46.0%, N exports is 60.8 - 108.9% higher compared to unfertilized wheat (average export 109.6 kg N / ha) and significantly improves the technological indicators of grain - crude protein content, wet and dry gluten, vitreous.

Mineral nutrition of barley

Barley has the highest soil requirements compared to other winter cereals. Barley has relatively good salt resistance and can be grown on saline soils.

To form a yield of 100 kg grain, 22.9 kg N (nitrogen), 1.1 kg P_2O_5 (phosphorus) and 1.7 - 2.4 kg K_2O (potassium) are needed то be absorbed from soil.

Winter malting barley is fertilized with less nitrogen than fodder barley (Table @@) so as not to increase the protein content of the grain, which impairs its technological properties. The protein content in the grain of malting barley should be up to 11% according to BSS (Bulgarian State Standard).

Mineral nutrition of rye

In order to form 100 kg of grain, the rye must absorb from the soil: 3.2 kg N, 1.4 kg P_2O_5 and 1.7 - 3.0 kg K_2O. Due to the high stem of cultivated rye varieties, it needs larger amounts of potassium than wheat and barley.

Foliar fertilization of winter cereals

For winter cereals, foliar fertilization can be applied during the joining (stem elengation) and heading phases with complex liquid fertilizers. The treatment can be done with airplanes or tractor sprayers, if the sowing is made with paths (rails). The effect of this fertilization is mainly to increase the amount of protein in the grain. The most suitable time for foliar fertilization is when the two uppermost leaves (the flag and below it) contain nitrogen below 4%. Wheat varieties with lower productive yield respond more strongly to foliar fertilization.

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Mineral nutrition of rapeseed

To form 100 kg of seeds and the corresponding above-ground mass, rapeseed extracts 5-6 kg N from the soil; 2-3 kg P_2O_5; 4-6 kg K_2O; 4 kg CaO; 4-7 kg S. During the first phases of its development (September-November) rapeseed needs a large amount of nutrients. It is a crop that is very responsive to high nitrogen fertilizers and extracts more nitrogen from the soil than cereals. Oilseeds absorb larger amounts of sulfur, so it is preferable to use sulfur-containing fertilizers such as ammonium sulfate and potassium sulfate.

Winter oilseed rape grows well in all regions of the country with an altitude of up to 800 m. It forms a weakly branched, deeply penetrating root system, which determines its preference for light soils. Wet, acidic and shallow soils are unsuitable. Fertilization tailored to the needs of plants has a positive effect on grain formation and yield.

Table 6. Recommended fertilizer rates for winter field crops kg/ha (according to Nikolova, M., 2010)

crop	expected yields t/ha	nitrogen (N)	phosphorus (P_2O_5)	potassium (K_2O)
wheat	**3 – 4**	**80 – 110**	**4- 60**	**70 – 90**
	5 - 6	**130 - 150**	**79 - 90**	**100 - 120**
barley	**3 – 4**	**80 110**	**50 – 60**	**80 - 100**
	4 - 5	**110 - 140**	**60 - 80**	**100 - 120**
malting barley	**3,5 – 4,5**	**60 - 90**	**60 - 80**	**90 - 110**
rye	**2 - 3**	**60 - 70**	**40 - 60**	**60 - 80**
oats	**2 -3**	**70 – 90**	**40 – 50**	**70 – 80**
	3 - 4	**90 - 120**	**50 - 70**	**90 - 100**
rapeseed	**2,0 – 2,5**	**100 - 120**	**50 –70**	**80 – 100**
	2,5 – 3,0	**120 - 140**	**70 - 100**	**100 - 120**

Mineral nutrition of spring, furrow crops

At spring, furrow crops 2/3 of the fertilizer rates of phosphorus and potassium are applied before the main tillage. The aim is to plow these fertilizers to a depth of 20 - 25 cm, the soil layer in which the main mass of the root system of the crops will develop. The rest of the rate is imported before the pre-sowing tillage. In this way, they are imported into the surface 10 cm layer and will provide the necessary amounts of the two elements for young plants that have an underdeveloped root system.

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This method of distribution of fertilizer rates for phosphorus and potassium is suitable for medium and light soils. If your soil is heavy clayed, the entire fertilizer rate for both elements can be applied with the main tillage in the fall. This is because these soils are characterized by greater natural fertility, which is why they can provide sufficient amounts of available phosphorus and potassium for the initial stages of crop development until they develop a deeper root system.

The nitrogen rate is divided into two, from 1/3 to 1/2 of it is imported before sowing, and the rest during vegetation. It is applied before the period of the most intensive growth of the crops, ie. at the moment when their need for the element is greatest (see figure 6). The effectiveness of the nitrogen norm can be increased if it is applied in three doses - 1/3 pre-sowing and two applications during the growing season.

Furrow crops respond well to organic fertilization. Manure should be applied in the autumn before the main tillage in the amount of 20-40 t / ha. Subsequent winter and furrow crops use the residual effect of manure, which decomposes in the soil over a period of two to three years.

Mineral nutrition of maize

The most suitable for maize are richer and deeper soils - chernozems, chromic luvisols and alluvial. Alluvial meadow, dark gray and cinnamon soils also develop well. The preferred soil reaction is neutral and slightly acidic (pH 6 -7).

In the initial periods of its development, maize absorbs the most nitrogen and potassium. By the beginning of flowering phase, corn absorbs 62% of the amount of nitrogen needed for the entire vegetation (Figure 6). Plants absorb nitrogen and potassium mainly in the tassel stage. Phosphorus is actively absorbed during seed formation, in the period of initial development and during the grain fill and their ripening.

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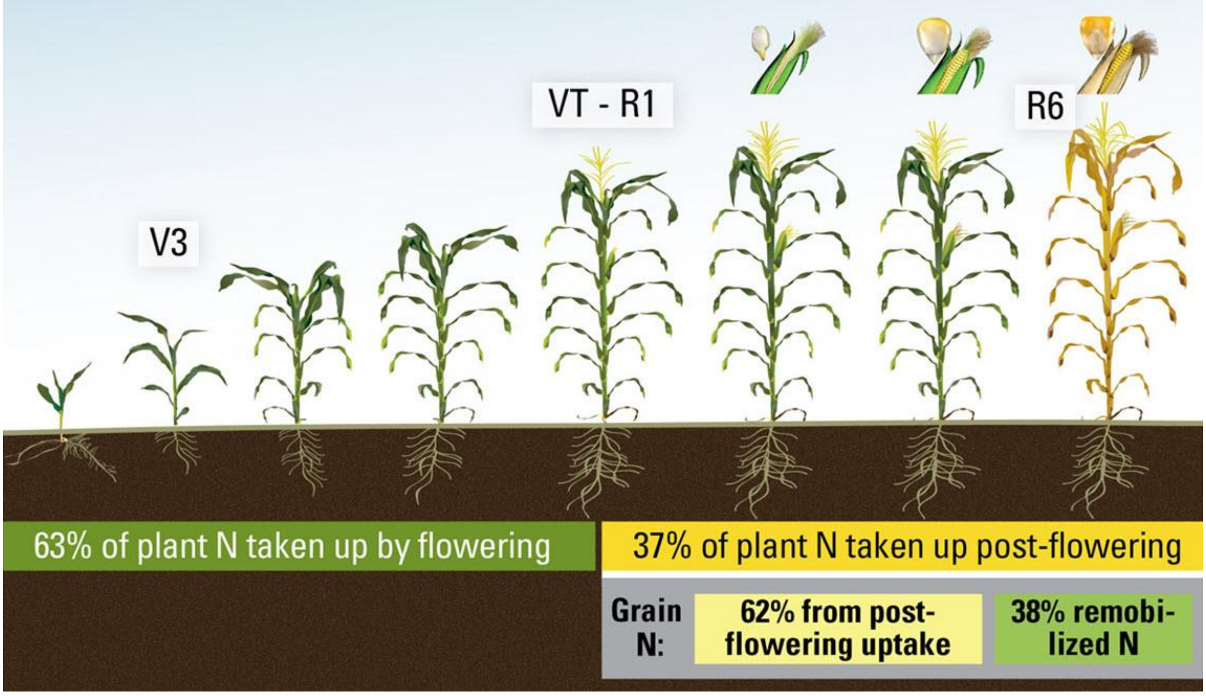

Figure 6. Absorption of nitrogen from maize during vegetation period

Source: https://www.pioneer.com/home/site/us/agronomy/library/n-uptake-corn/

To form 1 ton of grain with a corresponding amount of leaf mass in different early maturity hybrids, maize absorbs from the soil and fertilizers an average of 24-30 kg of nitrogen, 10-12 kg - phosphorus, 25-30 kg - potassium, 6-10 kg of magnesium and calcium, 3-4 kg of sulfur; 11 g of boron, 14 g of copper, 110 g of manganese, 0.9 g of molybdenum, 85 g of zinc and 200 g of iron. On chernozem soils, corn plants are able to provide 78% of their nitrogen needs, and phosphorus and potassium, respectively - 8 and 26%. The rest amounts should be added by fertilization.

The whole nitrogen rate for non-irrigated cultivation of corn is applied before sowing.

On irrigated and lighter soils, one third of the rate is applied before sowing, and the rest in phase 4 - 6 leaves, and апплиед with cultivators feeders in between rows.

During the growing season, corrective foliar fertilization with complex fertilizers that contain microelements can be applied. With these fertilizers the areas with маизе are sprayed twice - in phase 4 - 5th leaf and during tassel stage.

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Table 7. Recommended fertilizer rates for spring field crops kg / ha (according to Nikolova, M., 2010)

crop	expected yields t/ha	nitrogen (N)	phosphorus (P_2O_5)	potassium (K_2O)
Maize not irrigated	**3,5 – 5**	**90 – 120**	**50 – 60**	**80 – 100**
	5 - 6	**120 -150**	**60 - 80**	**110 - 130**
Maize irrigated	**7 – 8**	**170 – 200**	**90 – 110**	**150 – 180**
	Над 8	**200 - 240**	**120**	**180 - 220**
sunflower	**1,5 – 2,0**	**60 - 80**	**80 - 100**	**80 - 120**
	2,0 – 2,5	**80 - 100**	**100 - 120**	**120 - 140**
potatoes				
- medium early	**15 - 20**	**100 -120**	**80 - 100**	**12- - 160**
- late	**18 - 22**	**120 - 140**	**80 - 100**	**140 – 160**
	25 - 30	**140 - 160**	**100 - 120**	**160 - 180**

Mineral nutrition of sunflower

Sunflower is sown on different soils. Very heavy clay soils and very light sandy soils are unsuitable. It does not grow well on acidic and saline soils. The optimal soil reaction for sunflower is in the range pH 6 - 7.

Sunflower responds well to nitrogen fertilization. Excess nitrogen lowers the oil content and reduces the resistance of plants to diseases. Appropriate, balanced phosphorus and potassium fertilization increases yield and oil content in the seeds.

To form 100 kg of seeds and the corresponding above-ground mass, the sunflower extracts from the soil about 6 kg N; 2.6 kg P_2O_5; 11 kg K_2O. Sunflower absorbs twice as much potassium as nitrogen. It should not be fertilized with high levels of nitrogen, because the plants grow vigorously, suffer from more diseases and reduce the oil content in the seeds. Phosphorus enhances root development, increases the flowers in the combs, and the seeds accumulate more oil. Potassium helps to increase seed yield and oil content.

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5.6. Rules and rates for fertilizing vegetable crops

Vegetables grown in our country are characterized by great variation in species and varieties They have a different growing season (50 - 150 days), are grown in 2, and tomatoes in 3 productions directions (early, medium early and late). All of them require abundant fertilization due to high yields and their cultivation almost exclusively under irrigated conditions. The influence of fertilization is manifested not only on yields, but also on the quality of vegetables, the requirements for which are high.

The distribution of fertilizer rates for phosphorus and potassium is the same as for furrow field crops. The main part of the fertilizer rates of the two elements is applied before the main tillage, and the rest before the pre-sowing treatments.

The nitrogen rate is also divided into parts (doses). About 1/3 is imported before sowing, and the rest during vegetation period. Depending on the length of the growing season and the technology of growing the crop (field or greenhouse), not one but several nitrogen fertilizations are applied. The aim is to increase the efficiency of the fertilizer by reducing the unproductive losses of the element from evaporation or leaching in the lower soil layers.

Most vegetable crops are sensitive to chlorine, which decraesed the quality of production, so they should not be fertilized with chlorine-containing fertilizers, such as ammonium chloride or potassium chloride. Tomatoes, peppers, watermelons and melons are sensitive to chlorine.

Vegetable crops are very responsive to manure fertilization. It is also applied before the main tillage in quantities of 40 to 60 tons per ha on the depth of 20 – 25 cm. Depending on the availability of sufficient manure, fertilization in the above amount can be carried out every two years.

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Table 8. Recommended fertilizer rates for vegetable crops kg/ha

crop	expected yields t/ha	nitrogen (N)	phosphorus (P_2O_5)	potassium (K_2O)
tomatoes				
- early	55 – 65	200 – 260	120 – 200	100 – 150
- medium early	55 – 70	150 – 200	100 – 120	100 – 120
- late	30 - 35	160 - 200	100 - 120	100 - 120
pepper				
- early	12 – 15	150 – 200	100 – 120	100 – 120
- medium early	18 - 25	200 - 250	100 - 120	100 - 120
cucumber				
- early	30 – 40	12- 160	12- 180	100 – 120
- късни	25 - 30	100 - 160	80 - 100	100 - 120
aubergine	50 - 60	160 - 200	100 - 120	100 – 120
green peas	4 - 5	50 - 80	50 - 80	50 – 80
Green beans	6 - 7	60 - 90	80 - 100	100 - 120
headed cabbage				
- early	30 – 40	100 – 120	100 – 120	80 – 120
- and medium early	45 - 60	160 - 200	120 - 180	100 - 120
- late				
cauliflower	15 - 25	200 - 250	100 - 120	120 - 180
onion	20 - 30	80 - 100	160 - 240	150 - 230
garlic	15 - 25	70 - 100	80 - 100	70 - 100
leek	40 - 60	120 - 200	160 - 240	150 - 230
carrots	25 - 35	100 - 120	80 - 120	100 - 120
reddish	15 - 20	40 - 60	50 - 60	60 - 80
lettuce	20 - 25	40 - 80	50 - 60	50 - 60
spinach	20 - 25	80 - 100	60 - 80	70 - 100

Vegetable crops require harmonious fertilization with all the necessary elements, which pays off with high productivity and good market qualities. Mineral and organic fertilizers are used. Excessive fertilization with nitrogen if not supplemented with phosphorus, potassium and magnesium leads to

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low-value products, often high in nitrate. To avoid this problem, it is extremely important to determine the nitrogen level for vegetables on the basis of the mineral nitrogen content of the soil before sowing or planting.

5.7. Rules and rates for fertilization of perennial crops

Orchards and vineyards require regular fertilization to maintain the growth and fruiting of crops that have been absorbed nutrient by the same soil layer for years. The management of perennial nutrition is hampered by the fact that the absorption of nutrients is influenced by a number of biotic and abiotic factors such as varietal differences, rootstock (strongly or weakly growing), physical and chemical properties of the lower soil horizons, soil condition, surface (fallow or grasses/sod), age, density and training of the plantation and others. When developing an optimal program for fertilization, the production direction of the plantation is also essential - for fresh consumption or processing in orchards and for the production of wine or table grapes in the vineyards.

Recommendations for fertilization when creating new plantations

It is important to create an appropriate level of available plant nutrients in the soil before planting the trees. This applies mainly to phosphorus and potassium, and in many cases to magnesium. Pre-planting fertilization creates reserves of phosphorus and potassium in both the surface and deeper soil layers, which will be used by plants in the first years after planting.

Storage fertilization of the deeper soil layers is carried out by applying:

- for strongly growing rootstocks - 500 kg P_2O_5 and K_2O per ha;
- for weakly growing substrates - 300 kg $P_2O_5$and K_2O per ha;
- manure - 40-60 t / ha.

In young non-fruiting gardens, it is recommended to be fertilized only with nitrogen in order to maintain the growth of the trees before they start fruiting. In the first year after planting the trees, nitrogen fertilizer can be applied manually only around the stem of the tree. In this case the fertilizer rate can be halved.

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Fertilizer application

The main mass of the root system in the case of strongly growing rootstocks is located in the layer up to 1 m, therefore it is recommended to apply the phosphorus and potassium fertilizers with the deepest tillage, which is carried out before the establishment of the plantation. Weakly growing rootstocks are characterized by a shallower root system, due to which the fertilizers for storage fertilization are plowed to a depth of 50 cm. The application of manure should be done in the upper soil layers to a depth of 0-30 cm.

Fertilization of fruit-bearing plantations

The annual fertilization rates for fruit-bearing plantations are presented in Table 9. These rates are indicative and may vary depending on the variety, rootstock, growth strength, results of leaf analysis, irrigated or non-irrigated plantation, etc. Soil indicators, such as effective depth of root system development and soil moisture, also affect the need for fertilization.

Table 9: Annual rates for maintenance fertilization with good soil reserves of nutrients

Fruit species	Expected yield (t/ha)	Fertilizer rates (kg/ha)		
		N	P_2O_5	K_2O
apples	35	60 - 80	40 - 50	60 - 80
pears	15	60 - 80	40 - 50	60 - 80
cherry	15	60 - 80	50 - 60	60 - 80
peach	20	120 – 140	80 – 100	120 - 140
apricot	15	70 - 80	50 - 60	100 - 120
plums	25	80 - 100	60 - 80	80 - 100
raspberry	18	80–100	50 – 60	80 – 100
strawberry	10	60 – 80	50 – 60	60 – 80
chokeberry	8	60 - 80	50 - 60	70 - 90

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The annual rates of fertilization with nitrogen, phosphorus and potassium should be in accordance with the results of leaf analysis and adjusted if necessary.

Leaf analysis is a very suitable tool for determining nutrient deficiency or excess. The optimal levels of nutrient content for the main fruit crops are presented in Table 10.

Table 10. Optimal content of nutrients in the leaves of fruit crops (%)

Fruit species	Nitrogen (N)	Phosphorus (P)	Potassium (K)
apples	2.2 - 2.8	0.18-0.30	1.1-1.6
pears	2.2 - 2.8	0.15-0.30	1.0-2.0
cherry	2.1 - 2.8	0.16-0.30	1.6-2.0
peach	2.2 - 3.2	0.14-0.35	2.0-3.2
apricot	2.2 - 3.2	0.18-0.30	2.0-3.2
plums	2.2 - 3.2	0.18-0.35	1.6-2.5
raspberry	2.8 - 3.5	0.25-0.50	1.8-2.5
strawberry	2.5 - 3.2	0.25-0.40	1.5-2.5
chokeberry	2.2 - 3.0	0.25-0.40	1.5-2.5

Sources: Data on optimal nutrient content have been adapted from the books of Bergman (1992) and Jones et al, (1991).

Due to the existence of seasonal and other factors influencing the data from the leaf analysis, the recommended time for leaf sampling is July / August, when the intensive growth has ended.

Changes in the annual fertilizer rates (Table 9) are made when the values for the content of nutrients in the leaves deviate by more than 10% from the limits of the indicated optimal values in Table 10.

- In case of nutrient content below the optimal values, the basic fertilizer norms for the next vegetation period should be increased by 20% - increase by coefficient - 1.2.

- In case of nutrient content significantly above the optimal values, it is recommended to reduce or completely eliminate the fertilization with the respective element for the next vegetation or for several years ahead.

However, before deciding to change the fertilizer rates, other reasons must be sought that may have affected the absorption of nutrients, such as certain soil factors, severe drought, disease and others.

Determining the optimal terms for fertilizing of fruit crops

Nitrogen fertilization

Nitrogen fertilization is performed in several doses. It is recommended that half (2/3) of the fertilizer rate be applied at the beginning of the vegetation (end of February - beginning of March). The second half (1/3) should be applied at the end of May - beginning of June. The nitrogen norm can be applied in three doses as the third application is done in the fall. In these cases the rate is distributed respectively 50%, 25%, 25%.

Phosphorus and potassium fertilizers

It is recommended to apply the phosphorus and potassium fertilizers in the autumn - after the harvest before the soil freezes, with the deepest tillage. On soils with a lighter texture, potassium and especially magnesium fertilizers should be applied in early spring.

In orchards, foliar fertilization is recommended to provide trace elements in case of visible symptoms of the respective deficiency or established hidden deficit after foliar analysis. It is important to choose an appropriate formulation of foliar fertilizer, in accordance with the requirements of the species, stage of development or possible deficiency.

It should be noted that foliar fertilization serves as a supplement to the soil and makes sense mainly for the correction of micronutrient nutrition.

Vineyards

Recommendations for establishment of new plantations

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Phosphorus and potassium are key elements for the development of young vines. Deficiency of both elements in the soil can delay the entry of the plantation into fruiting. Therefore, it is recommended to create an optimal stock in soils with these elements, and in the period before the vineyard comes into fruiting to apply only small amounts of nitrogen fertilizers.

Pre-planting fertilization creates reserves of phosphorus and potassium in both the surface and deeper soil layers, which will be used by plants in the first years after planting. Storage fertilization of the deeper soil layers with phosphorus and potassium in the creation of new vineyards is carried out by application:

- 400 kg / ha P_2O_5 and K_2O
- application of manure - 20-30 t / ha

It is recommended that phosphorus and potassium fertilizers be applied with the deepest tillage, which is done before the establishment of the plantation (60 cm). The application of manure should be done in the upper soil layers to a depth of 0-30 cm.

Recommendations for fruit-bearing vineyards

Fertilization of vineyards can be based on basic norms (Table 11), consistent with the production direction of the vineyard (table or wine). The fertilization should ensure the maintenance of optimal levels of nutrients in the soil and in the leaves of the vineyards.

Table 11. Basic annual norms for maintenance fertilization at good soil stock and optimal values of leaf analysis for different types of vineyards

Type of vineyard	**Expected yield t/ha**	**Fertilizing rates**		
		N	**P_2O_5**	**K_2O**
table	12	120 - 150	100	120
wine	8	80 - 100	80	100

The figures in the table above serve as a guide in developing a program for fertilizing the vineyards. They should be updated expertly, taking into account some specific factors such as soil type, age of the vineyards, yield, variety, grape size, etc. The recommendations for the vineyards are in line with the requirement for obtaining quality wines, due to which the fertilizer rates are lower than those for the table vineyards.

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Correction of fertilizer rates based on leaf analyzes

Similar to fruit crops, leaf analyzes are a useful tool for diagnosing the nutritional status of vines. The optimal amounts of nutrients in the leaves of the vines are presented in table @@. Leaf samples are taken in the period from mid-June to mid-July. The leaves are taken from the middle of the annual shoots, located opposite the bunch of grapes.

Table 12. Optimal content of nutrients in vine leaves in%

Type of vineyard	N	P	K
table	2.3 - 2.8	0.25 - 0.45	1.2 - 1.6
wine	2.2 - 2.8	0.15 – 0.40	1.0 - 2.0

Sourses: The data on the optimal content of nutrients are adapted from the books of Bergman (1992) and Jones et al, (1991).

Adjustments are made when the values for the content of nutrients in the leaves deviate by more than 10% from the optimal values indicated in table 12

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- In case of nutrient content below the optimal values, the basic fertilizer rates for the next vegetation period must be increased by 20% - increase by coefficient - 1.2.
- In case of nutrient content significantly above the optimal values, it is recommended to reduce or completely eliminate the fertilization with the respective element for the next vegetation or for several years ahead.

As with fruit species, it must be clarified before proceeding to a change in fertilizer rates that the results of the leaf analysis have not been influenced by other biotic or abiotic factors.

Determining the optimal fertilization times

Nitrogen fertilization

Nitrogen fertilization is performed in several doses. It is recommended to apply half of the fertilizer rate when budding in early spring. The second half is good to bring in the phase of grain formation (May). A third nitrogen application can be made immediately after the grape harvest, in which case the total nitrogen norm is divided into three doses - 35%, 40%, 25%, respectively.

Phosphorus and potassium fertilizers

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The application of phosphorus and potassium is recommended to be done in the fall - after harvest before the soil freezes, with the deepest tillage.

On soils with a lighter texture, potassium fertilizers should be applied in early spring. In the case of vineyards, it is appropriate to apply foliar fertilization, mainly with microelements. It is important to choose an appropriate formulation of foliar fertilizer, in accordance with the requirements and the stage of development of the vine or with a possible established deficit.

6. EU policy in the field of fertilization and agriculture

Europe is the most urbanized continent in the world. Cities are not just engines of the economy, they are unsurpassed in providing the main factors for the quality of life in all its aspects: environmental, social, and cultural. However, all cities face a major challenge - reconciling economic activity and growth with cultural, social, and environmental considerations. The growth of cities and the spread of low-density settlements is one of the main threats to sustainable territorial development. In some areas, there is also a lack of sufficient incentives for the reuse of abandoned industrial land, which puts increasing pressure on unused land. Very often the value of soil, which is not considered a limited and non-renewable resource, is not valued.

Soil degradation has been one of the main environmental problems in many European countries for a long time. Due to unsustainable land use and pollution, as well as the impact of climate change, soils in Europe are at risk of erosion, loss of organic matter, pollution, loss of biodiversity, compaction, soil sealing, flooding, landslides, and salinization. Although soil degradation can in seen as a significant threat at European level, there is no legal instrument at EU level that deals directly with soil protection. In 2000, the European Union gave priority to soil protection under the 6th European Union Environmental Action Program. In 2002, the European Commission recognized soil protection as a specific policy area in the European Union and published a Communication "Towards a Thematic Strategy for Soil Protection" to achieve a comprehensive soil protection policy. Intensive efforts have been made at European level over the last two years to establish a comprehensive and integrated soil protection strategy.

Concerns about the protection and sustainable management of soil are not often directly reflected in the national environmental law of European countries. Especially little in national legislation is set aside for soil protection as an extremely fragile natural resource. Legal definitions of the environment do not systematically include soil among its constituent elements. Nevertheless, soil is sometimes mentioned in various documents as an element that requires the protection of vulnerable natural areas (forests, mountains) or as a component of the environment endangered by waste disposal.

International legislation does not also consider all the effects of the impact on the soil and tends to ignore it as such. European environmental policy originates from the European Council held in Paris in October 1972, at which the Heads of State or Government stated the need for a Community policy on the environment. The Council of Europe was the first European institution to issue a legal instrument on this subject with its resolution 19 of 30 May 1972. At the heart of this document was the soil for the first time and it is therefore known as the "European Soil Charter"

6.1. European Soil Charter 1972 (European Soil Chapter - Council of Europe, COE085046, Strasbourg, June 1972)

This official document emphasizes for the first time that soil is one of the most valuable assets for humans. It provides conditions for life and development of plants, animals, and humans. It is estimated that this absolutely and relatively limited resource can be degraded very easily. The European industrial society uses land for agriculture as well as for industrial development, urbanization of settlements and other activities. This imposes the need to preserve the soil and its quality for future generations.

The main contribution of the European Soil Charter is the attempt to define the role of national governments, regional communities, professional organizations and the individual in the conservation and sustainable use of European soils. The recommendations of the Council of Europe focus on:

- ✓ Farmers and foresters must apply production practices that preserve the quality of the soil.

Machinery and modern techniques permit considerable increases in yields, hut, if used indiscriminately, they may disrupt the natural balance of the soil, altering its physical, chemical, and biological characteristics.

- ✓ Soils must be protected against erosion.

Soil is exposed to the weather; it is eroded by water, wind, snow, and ice. Careless human activity speeds up the process of erosion by damaging the soil’s structure and its normal resistance to erosive action.

- ✓ Soils must be protected from pollution.

Certain chemical fertilizers and pesticides, used without discernment or control, may accumulate in cultivated land, and may thus contribute to the pollution of soil, groundwater, water courses, and air.

- ✓ Urban development must be planned so that it causes as little damage as possible to adjoining areas.

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Towns obliterate the soil upon which they stand and affect neighboring areas as result of providing the infrastructure necessary to urban life (roads, water supplies, etc.) and by producing growing quantities of waste which must be disposed of.

- ✓ In civil engineering projects, the impact on neighboring lands must be assessed in planning so that the necessary safeguards are included in the costs.

Operations such as the building of dams, bridges, roads, canals, factories, or houses may have a permanent influence on surrounding land, both close at hand and at a distance. They alter natural drainage and water tables. Such repercussions must be assessed so that suitable measures are taken to counteract damage.

- ✓ The full inventory and report of soil resources is publicly necessary.

For effective land planning and management and to permit the establishment of a genuine policy of conservation and improvement, the properties of the different types of soil, their capabilities and distribution, must be known. Each country must make an inventory, as detailed as necessary, of its soil resources.

- ✓ Future research and interdisciplinary collaborations are needed to ensure wise soil use and conservation.

Research on soil and its use must he supported to the full. On it depend the perfecting of conservation techniques in agriculture and forestry, the elaboration of standards for the application of chemical fertilizers, the development of substitutes for toxic pesticides, and methods of suppressing pollution.

- ✓ Soil conservation must be taught at all levels and be kept to an ever-increasing extent in the public eye.

Increasing publicity, adapted to national and local requirements, must be given to the need for conservation of the quality of the soil and the methods by which this aim can be achieved. Authorities should strive to ensure that the information given to the public by the mass media is scientifically correct.

- ✓ **Governments and those in authority must purposefully plan and administer soil resources.**

Soil is an essential but limited resource« Therefore, its use must be planned rationally which means that the competent planning authorities must not only consider immediate needs but also ensure long-term conservation of the soil while increasing or at least maintaining its productive capacity.

States which accept the principles set out above should undertake to devote the necessary funds to their implementation and promote a genuine soil conservation policy.

The 1987 Single European Act introduced a new section on the environment, which provided the first legal basis for a common environmental policy to preserve the quality of the environment, protect human health and guarantees rational use of natural resources. Subsequent revisions of the Treaties have further strengthened the Community's commitment to the environment, as has the role of the

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European Parliament in its development. With the Maastricht Treaty (1993), the environment became an official area of EU policy, the co-decision procedure was introduced and qualified majority voting in the Council became common practice. The Treaty of Amsterdam (1999) established the obligation to integrate environmental protection into all EU sectoral policies to promote sustainable development. "Combating climate change" has been identified as a specific objective in the Treaty of Lisbon (2009), as has sustainable development in relations with third countries.

EU environmental policy is based on the precautionary principle, the precautionary principle and the principle of source pollution, as well as the „polluter pays “principle. The precautionary principle is a risk management tool that can be applied when there is scientific uncertainty about an alleged risk to human health or the environment arising from a particular action or policy.

To counteract the large differences in the level of implementation among Member States, in 2001 the European Parliament and the Council adopted (optional) minimum standards for environmental inspections. For improving the enforcement of EU environmental law, Member States must apply effective, proportionate, and dissuasive criminal sanctions for the most serious environmental crimes.

The EU is an organization within the meaning of international law but differs from existing others in its activities. The EU is rather an "integration organization" with its own characteristics that distinguish it from other international organizations. What is most characteristic of the EU is that there is a voluntary and actual partial transfer of sovereignty, which means that the Member States have delegated part of their competences to the institutions established within the EU.

6.2. Updated "European Charter for the Protection and Sustainable Management of Soil 2003"

(CO-DBP (2003) 10, Strasbourg)

The overall conclusion is that there is a need for a generally accepted legal instrument, both at global and European level, to take responsibility for all aspects of soil protection and to assess and analyze all important soil functions for planetary life. The view is that the Soil Charter, drawn up by the Council of Europe in 1972, must be revised in to establish formal cooperation between European countries to follow the new initiatives of the European Union.

Europe can once again be the driving force for coordinated action to protect the soil. This can be done either through informal means, or through the adoption of a document encouraging appropriate action, or through the drafting of an international convention. It must identify the actions that need to be taken to establish full cooperation between the parties to make soil-related practical activities a national priority, because soil protection makes a crucial contribution to sustainable development.

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At its next meeting on 24 February 2002 in Budapest, the Council of Europe considered the draft revised soil charter, noting that, following the Commission's wish, the draft revised charter should not be legally binding. Some amendments were proposed to emphasize the incentive nature of the charter and it was decided to consider an amended version at its next meeting.

At its seventh meeting on 29 January 2003 in Geneva, the Council of Europe considered the new draft Charter, adopted it and decided to send it to the Committee of Ministers for adoption. At its meeting on 28 May 2003, the Committee of Ministers of the Council of Europe adopted a Revised European Charter for the Protection and Sustainable Management of Soil with the following structure and main elements:

1. Tools and measures for sustainable soil management provided by European countries to cooperate in promoting soil conservation policy:

A). Soil Inventory - Each country should make a complete list of its soil resources by setting up a soil research organization capable of organizing ongoing monitoring. The current state of the soil will be analyzed with the help of modern satellite monitoring techniques, appropriate maps and diagrams based on a geographic information system. Predictable changes in the soil must be constantly monitored. A coordinated European network of soil observatories for monitoring and monitoring in cooperation with the European Environment Agency should be established on since of monitoring European soils.

B). Soil research - States can undertake interdisciplinary research with a view to soil protection and sustainable management, focusing on:

- natural causes of soil degradation.
- anthropogenic causes of soil degradation, considering into account both aerial and terrestrial factors.
- monitoring and analysis of soil biodiversity and its importance for soil functions.
- impact of pollutants on the internal processes of the soil.
- simulation models to facilitate integrated soil management.
- interaction between society or certain groups of the population and the soils they use.
- know-how and knowledge possessed by soil users, especially among farmers.

Countries can exchange information and cooperate on current and future research programs, with a view to establishing a standard methodology and should contribute to the creation of a European soil data base.

C). Education - Interdisciplinary teaching of soil knowledge and its sustainable conservation must become part of the curriculum at all levels of education. Specific applied courses should be taught in

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the colleges of engineering, agronomy, forestry, and civil engineering, as well as part of continuing education for construction, industry, and rural communities.

D). Information - Providing public information about the need for sustainable soil protection and ways to achieve it, considering into account, the diversity and variability of specific local and regional pedagogical features. European countries are invited to cooperate to facilitate the exchange of data and information between them, as well as with relevant international bodies, in with the assistance of the European Environment Agency.

E). Participation - At national, regional, and local level, any decision, document, or measure affecting soil and land (provisions, planning, negotiation, implementation of projects) must be based on the principle of participation, with particular emphasis on:

- ❖ participation in decision-making, especially by women and local people.
- ❖ recognition that occupancy of land and its use for human activities necessitates involving all the parties in a locality in defining, implementing, and monitoring decisions and actions.
- ❖ public access to procedures for the settlement of disputes concerning or arising from land use.

G) Impact study

Impact studies relating to activities, plans or programs with a direct or indirect impact on soil need to include a soil study. This may include:

- ✓ systematically involve scientific analysis of the condition of the soil.
- ✓ assess the effects on soil quality in the short and the long term, both direct and indirect.
- ✓ check the biodegradability of substances or waste meeting into contact with the soil.
- ✓ note any irreversible effects.
- ✓ recommend means of preventing or limiting any foreseeable degradation.

2. Specific measures.

Where appropriate the states of Europe should take action to protect soil health and soil resources by, *inter alia*:

- restricting or prohibiting certain activities in protection zones; limiting use of heavy machinery on certain types of soil.
- prohibiting or regulating the spreading of fertilizers, pesticides, sewage sludge and liquid or solid animal waste.
- regulating landfill operations.
- regulating waste dumps.

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- regulating the deposit of rubble, mining waste or industrial waste (toxic or not).
- determining irreversibility thresholds.
- drawing up codes of good practice for soil management purposes, combining regulatory instruments and conditional incentive measures.
- openness in public information on farming practices and use of inputs.
- on-site monitoring of use of inputs.
- monitoring of mining and extraction activities.

6.3. Common Agricultural Policy (CAP)

The Common Agricultural Policy of the European Union (CAP) consists of a set of rules and mechanisms that regulate the production, trade and processing of agricultural products in the European Union, paying close attention to rural development. The CAP is one of the EU's most important policies. This is due to its high share in the EU budget - almost 50%, as well as the large number of people and the vast territory that are directly affected by it. The importance of the CAP is also determined by the fact that it is directly linked to the Common Market and the European Monetary Union, which are two key elements in achieving European integration. Today, the CAP is subject to reforms aimed at its market orientation and the promotion of sustainable agricultural and landscape-based farming methods aimed at improving food quality and safety.

At its meeting on 5 November 2020, the European Commission (EC) launched a public discussion on the roadmap for developing a "New European Soil Strategy - Healthy soil for healthy living".

It builds on the EU's new Biodiversity Development Strategy 2030 and focuses on updating the 2006 EU Thematic Strategy for Soils to tackle soil and land degradation in a comprehensive way, and to help achieve neutrality regarding to soil degradation by 2030, reduce erosion and increase soil organic matter. Significant progress is also needed in identifying contaminated sites, restoring degraded soils, determining the conditions for their good ecological status, and improving soil quality monitoring.

The European Commission clarifies that the objectives of the public consultation are:

• to maintain the level of soil fertility.

• to reduce soil erosion and compaction.

• to increase the organic matter in the soils.

• to identify contaminated terrains.

• to restore degraded soils.

• to determine what constitutes "good ecological status" for the soils in the individual

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areas.

The roadmap states that "*the European Environment Agency concludes that the lack of a comprehensive and coherent policy framework for land and soil protection is a key shortcoming that reduces the effectiveness of existing incentives and measures and may limit Europe's ability to achieve their future goals.* "

7. National soil legislation of Bulgaria

According to Art. 21 of the Constitution of the Republic of Bulgaria, the land is "basic national wealth". Arable land should only be used for agricultural purposes. A change of its purpose is allowed as an exception, if necessary and under conditions and order determined by law. This provision has, albeit indirectly, a bearing on the protection of agricultural land from pollution. The basic environmental law in this area remains the Law on the Protection of Air, Water and Soil from Pollution, adopted in 1963. With the entry into force of the special laws on the purity of atmospheric air and water, the normative act of 1963 now bears only the name Law for protection of the soil from pollution. It is called upon to regulate the public relations related to the implementation of the necessary measures to ensure the protection of the soil.

The ministries, departments and municipalities are assigned to carry out measures to protect the soil from pollution. The control over their implementation is assigned to the Minister of Environment and Water. The transitional and final provisions of the law stipulate that in all existing industrial enterprises, livestock farms and the like, treatment facilities must be built. For this purpose, programs are developed, which are approved by the Council of Ministers.

The land resources of the Republic of Bulgaria, harmoniously complemented by the favorable physical and geographical position, are among the most valuable natural resources of the country. The soil cover is characterized by great diversity due to the significant variety of soil formation factors. Bulgaria's soil resources, which generally have a high potential for productive, regulatory, and buffer functions, are naturally and anthropogenically subject to degradation, which adversely affects the functioning of ecosystems. Intensification in agricultural production can lead to acceleration of degradation processes - erosion, salinization, acidification, water pollution, reduction of biodiversity, to a degree unfavorable for agriculture and the environment. Damage to the soil is caused by its contamination with heavy metals and metalloids, plant protection products (pesticides), persistent organic pollutants, including petroleum products by unregulated dumping of waste on the soil surface, as well as by disturbance of lands and soils by the extractive industry.

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The main activities for soil protection are related to the harmonization of the Bulgarian with the European legislation in the field of protection, sustainable use and restoration of lands and soils; participation in the development of documents at European level; development of normative acts, strategies, programs, evaluations and analyzes; coordinating the activities undertaken under the UN Convention to Combat Desertification, the National Strategy and the Action Plan to Combat Desertification and Land Degradation and the measures for their implementation; implementation of preventive, current and subsequent control over the implementation of the provisions of the Soils Act and the by-laws.

The soil protection policy is implemented by the Ministry of Environment and Water and the Ministry of Agriculture and Food, assisted by the Directorate for Waste Management and Soil Protection in MEW, in accordance with the legislation of the European Community and the national legislation - Law on Environmental Protection. Environment, Soil Act, Agricultural Land Protection Act, Waste Management Act, Protection against the Harmful Impact of Chemicals and Preparations Act, Strategic Documents - National Action Program for Sustainable Land Management and Combating Desertification 2014-2020.

The main activities for soil protection are related to the harmonization of the Bulgarian with the European legislation in the field of protection, sustainable use and restoration of lands and soils; participation in the development of documents at European level; development of normative acts, strategies, programs, evaluations and analyzes; coordinating the activities undertaken under the UN Convention to Combat Desertification, the National Strategy and the Action Plan to Combat Desertification and Land Degradation and the measures for their implementation; implementation of preventive, current and subsequent control over the implementation of the provisions of the Soils Act and the by-laws.

Sustainable land management is a matter of balance to jointly maintain the functions of land resources for the benefit of the environment and society. The strategic national documents for soil protection are:

- ✓ National Program for protection, sustainable use and restoration of soil functions (2020-2030)
- ✓ National Action Program for Sustainable Land Management and Combating Desertification in the Republic of Bulgaria (update for programming period 2014-2020

I. LAWS

- ❖ LAW on Environmental Protection (promulgated in the State Gazette, issue 91 / 25.09.2002)
- ❖ SOIL ACT (Promulgated SG No. 89 of November 6, 2007)

- ❖ LAW on the responsibility for prevention and elimination of ecological damages (promulgated SG, issue 43 of 29.04.2008)
- ❖ LAW for protection of agricultural lands (promulgated SG, issue 35 of 24.04.1996, amended and supplemented, issue 39 of 20.05.2011)
- ❖ LAW on Plant Protection, (promulgated, SG No. 91 of 10.10.1997, amended and supplemented, SG No. 28 of 5 April 2011)

II. RULES

- RULES for application of the Law for protection of the agricultural lands (promulgated, SG, issue 84 of 4.10.1996, amended, issue 50 of 01.07.2011)

III. ORDINANCES

- ✓ ORDINANCE № 26 of 2.10.1996 for reclamation of disturbed terrains, improvement of low-productive lands, withdrawal, and utilization of the humus layer, (promulgated SG, issue 89 of 22.10.1996, amended and supplemented - issue 30 of 2002)
- ✓ ORDINANCE № 3 of 1 August 2008 on the norms for permissible content of harmful substances in soils (promulgated SG No. 71 of 12 August 2008)
- ✓ ORDINANCE № 4 of 12 January 2009 on soil monitoring (promulgated SG No. 19 of 13 March 2009)
- ✓ ORDINANCE on the inventory and surveys of areas with contaminated soil, the necessary restoration measures, as well as the maintenance of the implemented restoration measures (promulgated, SG No. 15 of 16.02.2007, effective as of 17.08.2007)
- ✓ ORDINANCE on the procedure and manner of inventory, research, implementation, and maintenance of the necessary restoration measures on areas with damaged soils (promulgated SG No. 62 of 4 August 2009)
- ✓ ORDINANCE № 36 of 18.08.2004 on the terms and conditions for biological testing, registration, use and control of fertilizers, soil improvers, biologically active substances and nutrient substrates. Issued by the Minister of Agriculture and Forestry (promulgated, SG, issue 87 of 5.10.2004).

7.1. Law on Soils (promulgated SG No. 89 of 2007, last amended and supplemented, SG No. 98 of November 27, 2018).

This law regulates public relations related to soil protection and their functions, as well as their sustainable use and sustainable restoration as a component of the environment. Soils are a national treasure, a limited, and practically irreplaceable natural resource and their protection is a priority and obligation of the state and municipal bodies and of the natural and legal persons.

The purposes of the law are:

1. prevention of soil damage and violation of their functions.
2. permanent preservation of the functions of the soils.
3. restoration of the disturbed functions of the soils.

The protection, use and restoration of soils are based on the following principles:

- ✓ ecosystem and integrated approach.
- ✓ sustainable use of soils.
- ✓ priority of preventive control to prevent or limit damage to soils and their functions.
- ✓ application of good practices in soil use.
- ✓ the polluter pays for the damages caused.
- ✓ public awareness of the environmental and economic benefits of soil protection from damage and of the measures for their protection.

The state policy on protection, sustainable use, and restoration of soils at the national level is implemented by the Minister of Environment and Water, the Minister of Agriculture and Food, the Minister of Health and the Minister of Regional Development. In the implementation of the state policy under par. 1 shall participate according to their competencies also other interested ministers and heads of departments. The policy for protection, sustainable use and restoration of soils is implemented at the regional level by the regional governors, and at the local level - by the mayors of municipalities. The bodies under par. 1-3 ensure public participation in decision-making and development of strategies, programs and plans for conservation, sustainable use and restoration of soils.

7.2. Agricultural Land Protection Act; (promulgated SG, issue 35 of 24.04.1996, amended and supplemented, issue 39 of 20.05.2011, last amended and supplemented SG No. 83 of 9 October 2018)

This law regulates the protection against damage, restoration, and improvement of the fertility of the agricultural lands and determines the conditions and the order for change of their purpose.

Agricultural land is a major national treasure and is used only for agricultural purposes. The purpose of the agricultural lands is to be use for production of plant products and grazing of cattle in a way that does not harm soil fertility and health. The change of the designation of the agricultural lands is allowed only as an exception in case of proven need and under conditions and by order, determined by this law.

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The protection against damage, restoration, and improvement of the fertility of the agricultural lands shall be applied also for agricultural lands, included in the construction borders of the settlements, as well as for forest territories, which are used for production of plant production and for cattle grazing.

Owners and users of agricultural land are obliged to protect them from erosion, pollution, salinization, acidification, swamping and other damage and to maintain and increase their productive qualities.

The Ministry of Agriculture, Food and Forestry provides the owners and users of agricultural land with official information on:

- the productive, technological, environmental, and economic qualities of agricultural land, including their basic prices, as well as the potential risks of deterioration of these qualities due to erosion, pollution, salinization, acidification, and swamping.
- the protection of the soil cover and the inherent and ecological functions from damage.
- the obligatory restrictions on the use of the agricultural lands.
- pesticides, fertilizers, industrial or household waste, biologically active and other substances that are registered and approved for use, and the sanitary norms for their use, as well as for the substances prohibited for use.
- the quality of the irrigation waters, the sanitary norms, and the maximum admissible technological norms for their use, as well as for the waters prohibited for irrigation of the agricultural lands.
- the anti-erosion crop rotations for the eroded endangered territories.
- appropriate tillage systems and techniques.

The Ministry of Agriculture, Food and Forestry maintains an information system for agricultural soil resources. A special register for agricultural lands is created and maintained in the information system:

1. contaminated with heavy metals and metalloids, radionuclides, oil products and other organic pollutants, industrial, construction and household wastes
2. endangered by erosion, pollution, salinization, acidification, and swamping.
3. The register under para. 2 also contains information about:
    - natural and legal persons or their successors, causes of pollution.
    - restrictive and recommended land use regimes and regulations for elimination of violations.
    - humus landfills.
    - industrial waste suitable for reclamation and improvement of agricultural lands.

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  - short-term and long-term programs for improving the productive qualities of agricultural lands and their protection from erosion, pollution, salinization, acidification, and swamping.

The Ministry of Agriculture, Food and Forestry has the right to impose mandatory restrictions on the use of agricultural land if:

- damage to agricultural land.
- non-compliance of the produced plant or animal production with the hygienic norms.
- deterioration of the ecological functions of the soil cover and the quality of surface and groundwater.
- other cases provided by law.

The Ministry of Agriculture, Food and Forestry prescribes forest reclamation and hydrotechnical measures to protect the soil cover from water and wind erosion.

The owner is free to choose the way of using the agricultural land, if it does not change its purpose and does not harm his own land, the lands of other owners or the quality of surface and groundwater. When restrictions on the use of agricultural land are imposed by law, the owner, respectively the user, is obliged to comply with them.

Owners and users of agricultural land are responsible for:

- ✓ the compliance with the hygienic norms of the plant or animal production produced from the agricultural land.
- ✓ damage to agricultural land owned by other owners, as well as damage to the quality of surface and groundwater.

The users of agricultural lands are responsible for the burning of stubble and other plant waste on the agricultural land and are obliged to participate in their extinguishing.

Owners and users of agricultural land are entitled to tax and credit preferences when applying:

  - the obligatory restrictions on the use of the agricultural lands.
  - recommendations for protection of the soil cover and the inherent and ecological functions.
  - anti-erosion agricultural techniques.
  - systems of organic farming and agriculture with reduced use of herbicides, pesticides, and fertilizers.
  - projects for restoration and improvement of the productive qualities of the agricultural lands.

Individuals and legal entities are liable if their actions damage the quality or environmental functions of agricultural land.

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It is forbidden:

- ✓ the use of pesticides, mineral, foliar and micro-fertilizers, as well as biologically active substances that have not received biological and toxicological registration from the specialized commissions and councils of the Ministry of Agriculture, Food and Forestry, the Ministry of Health and the Ministry of Environment and Water.
- ✓ burning of stubble and other plant residues in agricultural lands.
- ✓ the use of organic sludge from industrial and other waters and household waste for import into agricultural lands without permission from the specialized bodies of the Ministry of Agriculture, Food and Forestry.
- ✓ the destruction or modification of constructed anti-erosion and hydro-ameliorative facilities without the explicit consent of the respective state bodies.

Waters that contain harmful substances and waste above the permissible norms may not be used for irrigation. The organizations that manage and supply water for irrigation, periodically check the quality of the water and in cases when harmful substances and residues are found above the maximum permissible norms, notify the users and stop the supply of water until its quality is restored. Water users for the period of suspension have the right to claim compensation for damages and lost profits by lawsuit.

Restoration and improvement of eroded, polluted, saline, acidified and swampy agricultural land is a set of activities or technologies that aim to:

- restoration of the disturbed ecological functions of the soil cover.
- reduction or elimination of health and veterinary risks from the use of plant and animal products.
- preservation and increase of soil fertility.

The restoration and improvement of eroded, polluted, saline, acidified and swampy agricultural lands is carried out and based on previously developed, agreed, and approved technologies and projects. The state shall bear the costs for elimination of the reasons for non-fulfillment of the recommendations for protection of the soil cover and the inherent and ecological functions when they are a result of the actions or inactions of state bodies or when the cause of the damage is not identified.

7.3. Environmental Protection law; (promulgated SG No. 91 of September 25, 2002, last amended and supplemented, SG No. 54 of June 16, 2020)

This law regulates public relations related to:

- ✓ the protection of the environment for present and future generations and the protection of human health.

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- ✓ the preservation of the biological diversity in accordance with the natural biogeographical characteristics of the country.
- ✓ the protection and use of the components of the environment.
- ✓ control and management of factors that harm the environment.
- ✓ exercising control over the state of the environment and sources of pollution.
- ✓ prevention and reduction of pollution.
- ✓ the establishment and functioning of the National Environmental Monitoring System.
- ✓ strategies, programs and plans for environmental protection.
- ✓ the collection and access to environmental information.
- ✓ the economic organization of the environmental protection activities.
- ✓ the rights and obligations of the state, municipalities, legal entities, and individuals for environmental protection.

The objectives of the law are achieved through:

- ❖ regulation of the regimes for protection and use of the components of the environment.
- ❖ control over the condition and use of the components of the environment and the sources of its pollution and damage.
- ❖ establishment of permissible norms for emissions and quality of the environment.
- ❖ management of environmental components and factors.
- ❖ performing an environmental impact assessment (EIA).
- ❖ issuing permits for prevention, limitation, and control of pollution.
- ❖ declaration and management of territories with special protection regime.
- ❖ development of the system for monitoring the components of the environment.
- ❖ introduction of economic regulators and financial mechanisms for environmental management.
- ❖ regulation of the rights and obligations of the state, municipalities, legal entities, and individuals.

Environmental protection is based on the following principles:

- o sustainable development.
- o prevention and reduction of the risk to human health.
- o priority of pollution prevention over subsequent elimination of the damages caused by it.
- o public participation and transparency in the environmental decision-making process.
- o awareness of citizens about the state of the environment.
- o the polluter pays for the damages caused.
- o conservation, development and protection of ecosystems and their inherent biological diversity.
- o restoration and improvement of the quality of the environment in the polluted and damaged areas.

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- prevention of pollution and damage to clean areas and other adverse effects on them.
- integration of environmental policy in sectoral and regional policies for economic development and public relations.
- access to justice in environmental matters.

The components of the environment are the atmospheric air, the atmosphere, the waters, the soil, the earth's bowels, the landscape, the natural objects, the mineral diversity, the biological diversity, and its elements.

Factors that pollute or damage the environment can be natural and anthropogenic substances and processes; different types of waste and their locations; risky energy sources - noise, vibration, radiation, as well as some genetically modified organisms. The management, protection, and control of the components of the environment and the factors influencing them shall be carried out in accordance with the procedure determined by this law and by the special laws on the components and factors of the environment.

The state policy on environmental protection is implemented by the Minister of Environment and Water. The Minister of Environment and Water may by order delegate powers to the Deputy Ministers, defining their functions, and authorize officials in connection with statements of intent and actions that are part of the relevant proceedings for the issuance of administrative acts and documents.

The state policy on environmental protection is integrated in the sectoral policies - transport, energy, construction, agriculture, tourism, industry, education, and others, and is implemented by the competent bodies of the executive power.

Competent authorities within the meaning of the law are:

- the Minister of Environment and Water.
- the Executive Director of the Executive Environment Agency.
- the directors of the regional inspectorates for environment and water (RIEW).
- the directors of the basin directorates.
- the directors of the directorates of the national parks.
- the mayors of the municipalities, and in the cities with regional division – also
- the mayors of the regions.
- district governors.

Competent to take the actions and activities provided by law are:

- on the territory of one municipality - the director of RIEW or the mayor of the municipality, and in the cities with regional division - the mayor of the region.
- on the territory of one district - the district governor or the director of RIEW.

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- on the territory of several municipalities within the scope of one RIEW - the director of the respective inspection.
- on the territory of several municipalities within the scope of different RIEWs - the Minister of Environment and Water.

Everyone has the right to access available environmental information without having to prove a specific interest. Environmental information is any information in written, visual, audio, electronic or other material form concerning:

- the condition of the components under Art. 4 and the interaction between them.
- the factors under Art. 5, as well as the activities and measures, including administrative measures, international agreements, policy, legislation, including reports on the implementation of environmental legislation, plans and programs that have or are able to have an impact on the components of the environment.
- the state of human health and human safety, insofar as they are or may be affected by the state of the components of the environment or, through these components, by the factors, activities or measures referred to in item 2.
- cultural and historical heritage sites, buildings, and facilities, insofar as they are or may be affected by the state of the components of the environment or, through these components, by the factors, activities or measures referred to in item 2.
- cost-benefit analysis and other economic analyzes and assumptions used in the measures and activities referred to in item 2.
- emissions, discharges, and other harmful effects on the environment.

The protection, sustainable use and restoration of soil ensure effective protection of human health and soil functions, considering that soil is a limited, irreplaceable, and practically non-renewable natural resource. The protection, sustainable use and restoration of the soil are aimed at:

- prevention of its damage.
- permanent preservation of its multifunctional ability.
- ensuring effective protection of human health.
- preservation of its qualities as an environment for normal development of soil organisms, plants, and animals.
- implementation of preventive control to prevent adverse soil changes and application of good land use practices.
- elimination and / or reduction of the harmful changes of its quality, caused by processes, damaging the soils, according to the requirements of the types of land use.

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Legal entities and individuals, owners and / or users of land properties, are obliged not to cause harmful changes in the soil in their own and neighboring land properties. The norms regarding the admissible content of harmful substances in the soil are determined by an ordinance of the Minister of Environment and Water, the Minister of Health and the Minister of Agriculture, Food and Forestry. Owners and users of land are obliged to take measures to prevent harmful changes that threaten the soil. Whoever causes harmful changes to the soil is obliged to restore at his own expense its condition prior to the damage. The owners and users of underground and above-ground networks and facilities of the technical infrastructure are obliged to maintain them in technical condition and not to allow pollution or other harmful change of the soil around them. The humus layer of the soil is placed under special protection.

7.4. Environmental assessment (Ordinance on the terms and conditions for carrying out environmental assessment of plans and programs); Prom. SG. issue 57 of July 2, 2004, last ed. SG. issue 70 of August 7, 2020)

The ordinance determines the terms and conditions for environmental assessment of plans and programs that are in the process of preparation and / or approval by the central and territorial bodies of the executive power, local self-government bodies and the National Assembly, hereinafter referred to as "environmental assessment". or "EA".

Environmental assessment implementation is mandatory for plans and programs that:

- ✓ are required under Art. 85, para. 1 of the Environmental Protection Act (EPA), or
- ✓ are included in Annex № 1 and outline the framework for future development of investment proposals under Annexes № 1 and 2 to the EPA,
- ✓ or represent significant changes to plans and programs under items 1 and / or 2, or
- ✓ are likely to have a significant negative impact on the protected areas of the Natura 2000 network according to a decision under Art. 20 of the Ordinance on the terms and conditions for assessing of the compatibility of plans, programs, projects and investment proposals with the subject and objectives of protection of protected areas.

The environmental assessment is performed in the following sequence:

- notifying the competent authority to determine the applicable EC procedure.
- assessment of the need for EC.
- defining the scope and content of the EC.
- preparation of an EC report.

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- conducting consultations with the public, interested bodies and third parties who are likely to be affected by the plan or program.
- reflecting the results of the consultations on the EC report.
- issuing an EC opinion.
- monitoring and control in the implementation of the plan or program.

Competent authorities for EC plans, and programs are:

✓ for the plans and programs approved by the central bodies of the executive power and by the National Assembly - the Minister of Environment and Water.

✓ for the plans and programs approved by the territorial bodies of the executive power or by the municipal council - the director of the respective regional inspectorate for environment and waters (RIEW) or the minister of environment and waters within their competence determined according to art. 10, para. 2 of the EPA or under the respective special law.

The environmental assessment (EC) of plans and programs is a preventive tool for assessing possible significant environmental impacts resulting from the implementation of plans and programs at international, national, regional, and local levels. The evaluation is performed simultaneously with their development, using the process integration approach. The implementation of the EC is fully compatible with the regulated national procedures for the preparation and approval of plans, and programs, and the bodies responsible for their approval must comply with the EC opinion and decision.

7.5. Environmental Impact Assessment (EIA); (SG, issue 3 of 2006, adopted by CMD №59)

The Environmental Impact Assessment (EIA) is the preventive tool for identifying possible impacts on the environment and human health from the construction and operation of investment proposals in all sectors of the economy and infrastructure development, at an early stage of their research and development, before a decision has been made for their implementation at a specific place with the respective technology, method of construction, etc. The results of the EIA must be considered in the design, construction, and operation of investment proposals.

Public participation becomes a mandatory and essential part of the EIA procedure in Bulgaria. The regulated regulatory requirements allow the public to express their opinion on the results of the EIA (and indirectly on the plan, and project or site in operation). This makes it possible to have an impact when making one or another decision - in relation to existing alternatives, proposing new alternatives, in some cases even for not allowing the implementation of the project or partial suspension of facilities.

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According to the Ordinance on the terms and conditions for carrying out EIA (SG, issue 3 of 2006, adopted by CMD №59), the procedure includes the following actions, carried out in the following order:

1. notification of the competent authorities and the affected population.
2. assessment of the need for EIA.
3. carrying out consultations; determining the scope, content and format of the EIA report.
4. assessing the quality of the EIA report.
5. organizing a public discussion of the EIA report.
6. making a decision on EIA.
7. exercising control over the implementation of the conditions and measures from the decision on EIA or the decision for assessment of the necessity of EIA.

The preparation of an EIA report is carried out by independent experts and with a public discussion. The EIA ends with a decision by the relevant competent authority for:

- permitting or prohibiting the implementation of the proposed project, or respectively,
- continuation or transfer of the operation of an existing business site.

EIA is carried out in accordance with the current legislation in the field of environment: laws, regulations, hygiene, environmental, technical, urban planning and other norms and standards.

Any EIA Decision, whether positive or negative, may be appealed by persons who have a legal interest in it, within 14 days of its publication under the relevant law. In case of negative decisions, this is the assignor of the investment proposal. Recently, it has become quite popular to appeal against the positive decisions of various environmental organizations.

The appeal procedure is carried out through the administrative body that issued the decision to the generically competent administrative court. The court proceedings are two instances, as the decisions of the administrative courts are subject to appeal before the Supreme Administrative Court (SAC), and the decisions of a three-member panel of the SAC as a first instance are appealed before a 5-member panel of the SAC.

The question of the generality and differences between environmental assessment (EC) and environmental impact assessment (EIA) often arises. In principle, both assessments are prepared in accordance with the provisions of the Environmental Protection Act (EPA), and both have a procedure for assessing the need to perform them when they are outside the scope of mandatory assessments and are likely to have significant negative impact on the components of the environment - atmospheric air, atmosphere, water, soil, subsoil, landscape, natural sites, mineral diversity,

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biodiversity, and its elements. The conditions and the order for their implementation are determined by ordinances of the Council of Ministers.

The difference between the two assessments is that the Environmental Assessment is strategic and is carried out for plans and programs that are in the process of preparation or approval by central and territorial bodies of executive power, local self-government bodies and the National Assembly.

7.6. Complex permit (Ordinance on the terms and conditions for issuing complex permits, adopted by the Council of Ministers № 238 of 02.10.2009)

Complex permits (CoR) have been established as a procedure in Bulgaria since 2002, which was established by the Environmental Protection Act (EPA). The procedure under which they operate is determined by an ordinance adopted by a Decree of the Council of Ministers. The ordinance regulates the conditions and the procedure for issuing complex permits under Chapter Seven, Section II of the Environmental Protection Act (EPA) for the construction and operation of new and for operation and significant changes of existing installations and facilities, for the category’s industrial activities under Annex № 4 to the EPA. The ordinance also determines:

- the content and form of the applications for issuing complex permits.
- the procedure and method for determining the best available techniques (BAT).
- the procedure and the manner for review, updating and revocation of issued complex permits.
- the order and the manner of reporting the emissions of harmful substances.
- the conditions for the monitoring under art. 123, para. 1, items 4 and 7 of the EPA and the obligation to provide the respective information for the bodies responsible for carrying out the control under Art. 120, para. 5 EPA.
- the content and the form of the information under art. 123c, item 1 of the EPA.

A complex permit is issued in compliance with the following order:

1. submission of an application for issuance of a complex permit.
2. examination and verification of the received application, supplementing the application, if necessary, and providing access to the application to the interested persons, including in the countries affected by the activity of the installations in case of cross-border transmission.
3. issuing the complex permit and ensuring access of the interested persons to the permit, including in the countries affected by the activity of the installations in case of cross-border transmission.

When considering the received application, the competent authority under Art. 120, para. 1 of the EPA checks whether the operator has planned / implemented the necessary measures for prevention

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and control of pollution in accordance with the requirements of the ordinance, paying attention to the following criteria:

- ✓ assessment of the possibilities for reducing the consumption of energy, water, and raw materials.
- ✓ evaluation of the measures for optimization of the production process.
- ✓ assessment of the measures for prevention of waste generation, and where this is not possible - of the potential for their recovery.

The competent authority under Art. 120, para. 1 of the EPA shall issue the complex permit, after the inspection under para. 2 found that:

- the operator has planned / implemented the necessary measures for prevention and control of pollution by applying the best available techniques within the meaning of the EPA.
- the operation of the installations and facilities will not cause violation of the norms for quality of the environment.

In accordance with the requirements of the latest changes in the European and national legislation on complex permits, an information system has been developed to maintain a register of the results of the issuance, refusal, revocation, review, amendment and updating of complex permits.

The new system provides public access to the information on the issued complex permits and the decisions on the procedures, to the technical assessments with information on the set conditions of the permit, as well as information on the measures taken by the operators upon final termination of the activities for which a complex permit is required.

7.7. National Program for protection, sustainable use, and restoration of soil functions (2020-2030)

The Bulgarian government in accordance with the development of European environmental policy discussed and adopted at its meeting on October 21, 2020. National Program for protection, sustainable use, and restoration of soil functions for the period 2020-2030. The program is developed in accordance with Art. 24 para. 1 of the Soils Act and Art. 77 of the Environmental Protection Act. It defines the main goals and measures for practical application of the state policy for protection of soil resources at national, regional, and local level.

The aim of the National Program is protection of soil resources and their sustainable use, as well as application of good practices for prevention of soil damage. It covers a 10-year implementation period and includes a five-year action plan.

The policy for soil protection in Bulgaria is based on the following principles:

- ✓ ecosystem and integrated approach.

- ✓ sustainable use of soils.
- ✓ preventive control to prevent or limit damage to soils and their functions.
- ✓ application of good practices in soil use.
- ✓ the polluter pays for the damages caused.
- ✓ public awareness of the environmental and economic benefits of soil protection from damage and measures for their protection.

Main criteria for determining the priorities in the National Conservation Program, according to Art. 24, para. 4 of the PA, sustainable use and restoration of soils are:

- ❖ Sustainable use of soils as a natural resource.
- ❖ Preservation and improvement of soil fertility.
- ❖ Reduction of harmful effects on soils caused by natural processes and phenomena and anthropogenic factors.
- ❖ Prevention and reduction of the risk for human health and protection of the other components of the environment.
- ❖ Observance of the principles of sustainable development, including the principles of organic farming.
- ❖ Restoration of disturbed soil functions.
- ❖ Obligations assumed by the state under international acts relating to soils.

Appendix 1

Soil profile

The soil profile is a vertical section of the soil, showing the horizons and the forming material (Figure 7). Genetic horizon is a homogeneous layer of soil, enclosing the soil profile with similar morphological features, composition, properties and fertility. The transition from one horizon to another occurs gradually in soils formed under grassy vegetation and more abruptly in soils formed under forest vegetation.

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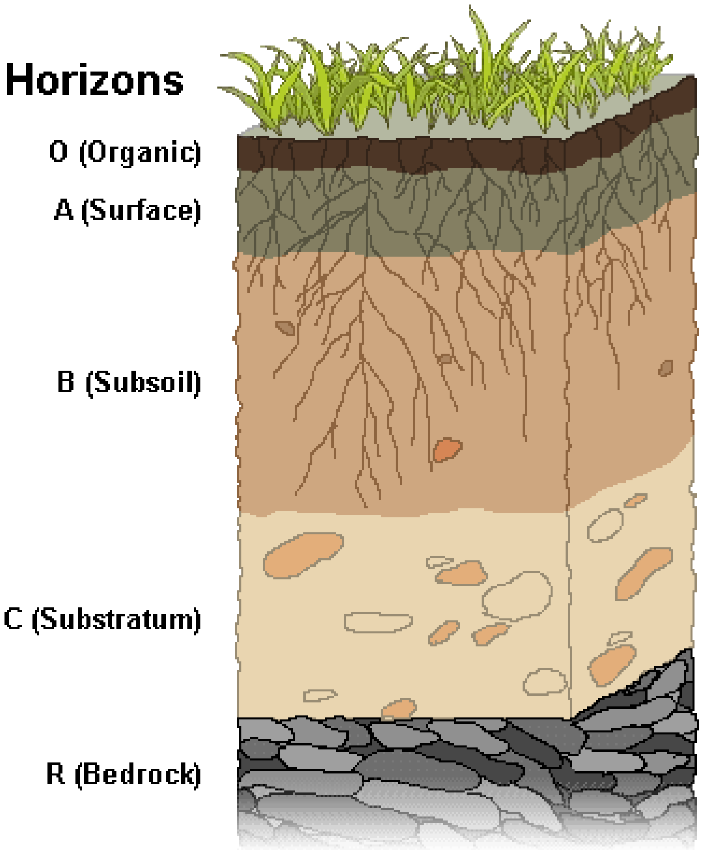

Figure 7. Soil profile

Source: https://en.wikipedia.org/wiki/Soil_horizon

In general, there are 3 main soil horizons and one thin surface layer:

Horizon 0 - extending from 0 to 2 cm, represents the loose, biologically highly active part of the soil;

Horizon A - at a depth of 10-25 cm. It is called humus horizon or arable horizon, it is called lithobiosphere

Horizon B - at a depth of up to 35-40 cm. In this horizon the root system of plants develops and is called the rhizosphere.

Horizon C - at a depth of up to 250-300 cm, but most often up to 40-50 cm. It is called the main rock.

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This study was produced with the assistance of the European Union through the Interreg-IPA CBC Bulgaria -Turkey Programme, CCI No 2014TC16I5CB005. The contents of this publication are the sole responsibility of KRIB Haskovo and can in no way be taken to reflect the views of the European Union or the Managing Authority and the National Authority of the Programme.