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Adaptation to climate change in agricultural sector - a proposal for rational management measures

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Abstract

Agriculture, as one of the most important branches of economy, depends on climate conditions and has a significant contribution to climatic changes process, primarily by releasing greenhouse gases (GHG). It is estimated that agriculture directly emits about 9% of the total amount of GHG, of which 5% originates from soil and about 4% from livestock production (ruminants). Emissions of carbon dioxide into the atmosphere from cultivated soil are 27% to 90% higher compared to natural grasslands. For greater climate neutrality of agriculture, two-way action is necessary: towards the reduction of GHG and towards the sequestration of carbon in the soil. Recommended measures and practices in the management of organic carbon content in soil include a wide range of agronomic, biological, technical and technological procedures, management and structural practices on agricultural soil. By encouraging organic plant production, which should contribute to maintaining and increasing the natural fertility of the soil, as well as preserving and improving biodiversity and stabilizing the structure of the soil, it can contribute to mitigating climate change.

Keywords: climate change, GHG, measures of more rational soil management

Introduction

Soil is a natural resource that arises as a result of the joint and mutual effects of the lithosphere, atmosphere, hydrosphere, and biosphere. It plays an important role in the global cycle of carbon, nitrogen and other elements in nature and is the source of the three most common greenhouse gases (GHG): nitrogen suboxide (N_2O), methane (CH_4) and carbon dioxide (CO_2). The observed climate change Prather and Ehhalt (2001) is attributed to increased GHG emissions. Anthropogenic disturbance of natural ecosystems has led to an increase in GHG emissions, which have escalated from changes in soil use, intensification of agriculture and soil management. It is estimated that agriculture directly emits about 9% of the total amount of GHG, of which 5% originates from soil, and about 4% from livestock production (ruminants).

Climate change resulting from extreme droughts or floods is becoming more pronounced and as such has a major impact on soil degradation. Adopting the practice of sustainable soil management can be part of the solution when it comes to reducing GHG emissions into the atmosphere and adapting to changed climatic conditions (Manojlović and Pivić, 2020; Ikanović and Popović, 2020; Popović et al., 2020). As soil is an integrated part of the food, energy and water network, it is a

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functional component of environmental sustainability, which is associated with climate change, declining biodiversity, water, energy and food security (Bouma 2014; Gupta et al. 2019).

In the past and this century obviously, anthropogenic activity has led to climate change. Compared to the pre-industrial period, to date, the temperature on Earth has increased by about 1˚C (0.8-1.2˚C). Estimates point to predictions that the global average temperature will increase between 1.8˚C and 4 ˚C by 2099 (IPCC 2018). Projections of regional climate models according to two IPCC scenarios of GHG emissions, RCP8.5 and RCP4.5, predict further increase in temperature, change in precipitation regime, as well as intensification and higher frequency of extreme events.

The IPCC report (2001) indicates a direct link between anthropogenic activities and observed climate change. Globally, as a result of burning fossil fuels and cement production, from 1850 to 1998, approximately 270 ± 30 Pg CO_2 was released into the atmosphere Lal (2004), while changes in soil use, in the same period, in atmosphere was released 136 ± 55 Pg CO_2 (IPCC, 2001). During the 1990s, total C emissions consisted of fossil fuel combustion, amounting to 6.3 ± 0.3 Pg C per year and 1.6 ± 0.8 Pg C per year, released due to change in soil use. Of the total amount released of 7.9 Pg C per year, 3.3 ± 0.2 Pg C per year was accumulated in the atmosphere, 2.0 ± 0.8 Pg C per year in the oceans, while 1.9 ± 1.3 Pg C per year has accumulated in the terrestrial ecosystem (IPCC, 2001). In the long run, the concentration of CO_2 in the atmosphere has increased from 180 to 280 ppm since the last glacial period, i.e. adding 220 PgC to the atmosphere over a period of 10.000 years, with an increase of 4.4 PgC per year (Baldocchi et al. 2016).

Temperature and precipitation are the most important factors controlling the dynamics of organic matter content (SOC) (Deb et al. 2015). Although an increase in temperature can have a positive effect on crop production, increasing carbon uptake into the soil (due to higher residue mass), microbial decomposition of SOC (so-called priming effect) also increases, Keestrea et al. (2016). According to Crovther et al. (2016), an increase in temperature will stimulate net carbon loss in the soil by switching to the atmosphere and accelerate climate change (Figure 1).

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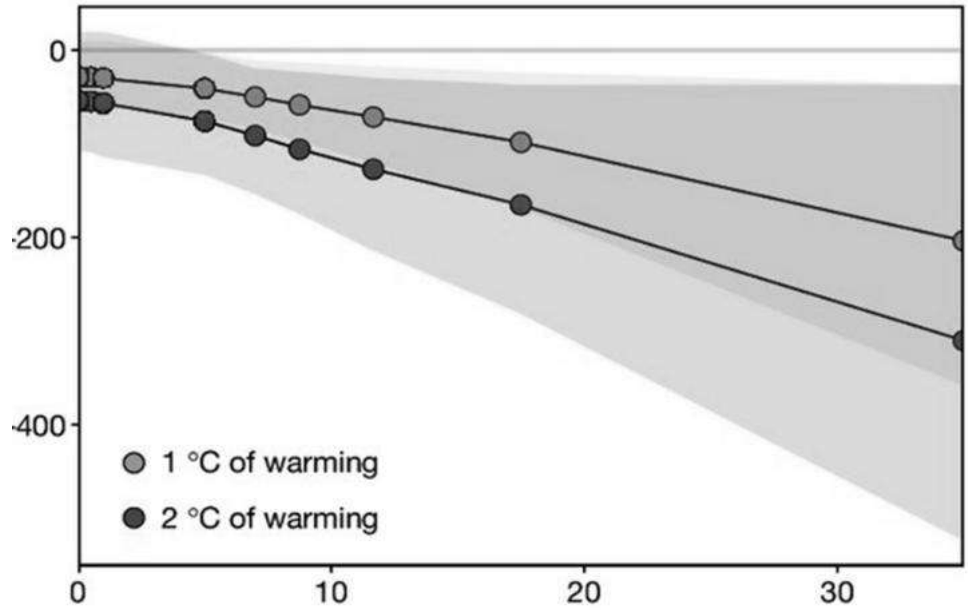

Figure 1. Total reduction of global reserves C with 1°C and 2°C of soil surface warming expected by 2050, in a number of different scenarios of weather impact off soil X axis: Impact-time (years), refers to the speed at which full impact will be achieved; Y axis: Estimated loss of C by 2050 (Pg); shaded areas indicate a 95% confidence interval around the average C (point) loss for each scenario (adapted from FAO and ITPS 2015).

With climate change, more frequent extreme rainfall and drought events are predicted that may have a greater impact on ecosystem dynamics than single or combined effects of rising CO_2 and temperature (IPCC 2014). This increase in the frequency of extreme events can increase the speed and susceptibility to accelerated erosion, salinization, and other degradation processes, leading to further carbon losses.

Materials and Methods

The proposal of measures for mitigating the impact of intensive agricultural production on climate change is given on the basis of available literature, ie given guidelines of the IPCC and FAO.

Results and Discussions

According to some estimates, agricultural production is thought to be responsible for a quarter of global anthropogenic GHG emissions. Intensive agricultural production can cause the loss of organic matter and intensification of soil erosion, which releases CO_2, contributing to global warming and the emergence of climate change.

According to Đurđević et al. (2018), in the period from 1961 to 2017, in the Republic of Serbia, the trend of temperature increases of 0.36°C per decade was observed, and in the period from 1981-2017, 0.6°C per decade. In the same period, the amount of precipitation increased to 10%, and in the South of the country to 20% compared to the reference period. The changes were more pronounced during the summer season, which became warmer by about 2.5°C, while summer

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precipitation decreased by 10 to 20% in most parts of the territory, to 30% in the South. Extreme occurrences of extreme events, heat waves, drought, floods, and intense precipitation, have also been observed.

According to Maksimović et al. (2018) mean air temperatures of 18.6°C were observed during the vegetation period according to the 30-year data (1987-2016) collected in Bački Petrovac. Compared to data from the previous period (1948-1990), increase in mean daily air temperatures is observed in all the months, especially July and August (1.4°C) as well as throughout the whole vegetation period (1.0°C)

There are two ways to reduce the increase in GHG concentration in the atmosphere: reducing CO_2 and N_2O emissions and/or their binding (immobilization) in the soil. Some measures of agricultural production have a positive effect on reducing the concentration of CO_2 in the atmosphere by its binding by the process of photosynthesis and the accumulation of organic carbon compounds in the soil after the death of plants. Carbon sequestration, which presents the storage of carbon from the atmosphere into the soil, can contribute to mitigating climate change. The strategy includes increase in the content of soil organic matter through greater biomass production and the development of the root system of plants, as well to encourage humification and the formation of an organo-mineral complex that improves and stabilizes soil structure.

Climate change mitigation refers to changes in management strategy, behavioral changes and technological innovations that reduce GHG emissions. In this way, soils can play an integral role in reducing CO_2 emissions due to their carbon storage potential (Lal 2004). On the other hand, adaptation to climate change refers to efforts aimed at achieving greater resilience to climate conditions that help human and natural systems to adapt to changing climate (IPCC 2014). In contrast to mitigation, adaptation measures can be both reactive and proactive, and the benefits presented are usually local and short-term (IPCC 2007). Currently, due to the already present warming, adjustment measures are needed despite the higher associated financial costs, regardless of the extent of mitigation efforts (IPCC 2007). Given the role of soil in climate change mitigation and adaptation and the constraints of SOC saturation in the accumulation of additional carbon inputs, sustainable soil management needs to be implemented to ensure that soil becomes a reservoir, and not a source of atmospheric CO_2 (Paustian et al. 2016). For this reason, it is necessary to study and determine, for different ecosystems, the current SOC reserves and the appropriate point of carbon saturation in order to determine the potential for carbon sequestration in soil.

Sustainable soil management is the basis of sustainable agriculture and is a strategic component of sustainable development. Studies show that by degradation of a third of the world's soil, up to 78 Gt of carbon has released in the atmosphere. Anthropogenic CO_2 emissions of 25% are absorbed by the ocean, while deeper soil horizons/layers can store 760 to 1520 Gt of additional carbon (FAO 2017). In addition to the above, the change in the purpose of soil cover, the so-called

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anthropogenic reduction of agricultural soil, which primarily refers to the transfer from natural or semi-natural to arable agricultural soil, leads to a decrease in the concentration of organic carbon. Sustainable soil management practices can be applied to any ecosystem or type of soil use (Znaor 2019). The results of scientific research projects and numerous examples of good practice from all over the World testify to that.

One example of a new green model, shown in Table 1, is carbon sequestration in agriculture and encouraging practices that store CO_2 in soil organic matter by binding it to a stable humus fraction (Ugrenović et al. 2020; 2021).

Table 1. Proposed methods for reducing GHG emissions and encouraging carbon sequestration

Expected goals	Methods
Reduction of GHG emissions	Input management: - increased participation of legumes in the crop rotation, - wider crop rotation with the inclusion of green manures; Reduction of energy consumption on the farm: - application of reduced, conservation tillage; Management of plant residues and organic fertilizers, composting. Crop management and optimization of fertilizer use.
Encouraging carbon sequestration in soil	Inclusion of cover crops, green mulch and green manure in crop rotation. Introduction of protection belt methods. Agroforestry.

Conclusions

Recommended measures and practices in the management of organic carbon content in the soil include a wide range of agronomic, biological, technical-technological procedures, management and structural practices. Recommended measures for the preservation of organic matter in the soil, and thus alleviate soil degradation and impact on the GHG reduction, may be as follows:

- afforestation (organic carbon sequestration process);
- lawning (have a great potential to store additional amounts of carbon and can act as carbon reservoirs for more than 100 years, after which most of them reach a balanced C amount);
- maintenance of lawns (application of manure and plant residues of grass on lawns; defining grazing plan and number of animals that are optimal for breeding; growing legumes, fertilizer management, pasture cultivation with a chain harrow, sowing, etc.);
- use of peatlands as a type of agricultural soil (prevention of degradation by banning drainage, plowing and burning of plant residues, as well as limited exploitation);
- ban on burning crop residues (straw, corn and other crop residues);
- tillage in a way that reduces degradation processes, especially its erosion (on agricultural soil with a large slope of, e.g. 15% or more, plowing must be carried out only perpendicular to the slope, ensuring the existence of plant cover during rainy periods on plots in areas with a slope higher than prescribed);

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- soil cover with cover crops, crop residues or mulching (these are multifunctional measures to prevent and/or reduce soil compaction and erosion caused by wind (which can be a problem in flat, loose and dry areas, especially on bare sandy and peat soil), or by water, which also contributes to reducing carbon and nitrogen losses and translocations to surface and groundwater)**;**
- growing a large number of different cultures;
- application of crop rotation (method of agricultural production recognizable for organic agriculture, which, in addition to the above, includes the use of compost and other breeders that maintain the content of organic matter in the soil at an optimal level).

The application of these measures enables and encourages the accumulation of organic carbon in the soil, contributes to the protection and preservation of terrestrial biodiversity and mitigation of climate change.

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Adaptacija na klimatske promene u sektoru poljoprivrede - predlog mera racionalnog upravljanja

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Izvod

Poljoprivreda, kao jedna od najvažnijih grana privredne delatnosti, zavisi od klimatskih promena, ali ima i znatan doprinos u navedenom procesu, pre svega ispuštanjem gasova sa efektom staklene bašte. Procena je da poljoprivreda neposredno emituje oko 9% od ukupne količine GHG, od čega je 5% poreklom iz zemljišta, a oko 4% iz stočarske proizvodnje (preživari). Emisija ugljen dioksida u atmosferu iz obrađenog zemljišta veća je za 27% do 90% u poređenju sa prirodnim travnjacima. Za veću klimatsku neutralnost poljoprivrede neophodno je dvosmerno delovanje: ka smanjenju GHG i ka sekvestraciji ugljenika u zemljištu. Preporučene mere i prakse, u upravljanju sadržajem organskog ugljenika u zemljištu obuhvataju širok spektar agronomskih, bioloških, tehničko-tehnoloških postupaka, upravljačkih i strukturnih praksi na poljoprivrednom i neobradivom prirodnom zemljištu. Podsticanjem organske biljne proizvodnje, koja treba da doprinese očuvanju i povećanju prirodne plodnosti zemljišta, kao i očuvanju i unapređenju biodiverziteta i stabilizaciji strukture zemljišta, može se doprineti ublažavanju klimatskih promena.

Ključne reči: klimatske promene, GHG, mere racionalnijeg upravljanja zemljištem

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