7th Workshop

SPECIFIC METHODS FOR FOOD SAFETY AND QUALITY

September 22nd 2021, Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

PROCEEDINGS

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THE ROLE OF SUSTAINABLE AGRICULTURE IN PRODUCTION OF NUTRIENT DENSE FOOD

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ABSTRACT
Industrialization of agriculture, as the main food source, resolved the problem of food quantity, but other problems, present in environment degradation and hidden malnutrition (deficiency in essential minerals and vitamins) were upraised. The situation is aggravating when climate change was taken into account, whereas conventional agriculture is highly contributing to climate change. Thus, a shift to sustainability paradigm and systems are a necessary solution. Sustainable systems combine various measures to achieve a high and nutrient dense yield of agricultural crops and to preserve or improve agro-ecosystem. Soil recovery could be realized by increasing soil organic matter, diversity of soil microbiota and other organisms, as a part of the agro-ecosystem balance, thus contributing to the increased productivity and food quality. Together, sustainable agriculture and sustainable food systems, have an important role in the health enhancement of humankind and the agro-ecosystem.

INTRODUCTION
Agro-industry, as a part of the global economy, focussed on food/feed production, incorporated many technological improvements, such as agricultural machinery, tools that are able to reduce labour energy, irrigation systems, numerous agrochemicals (fertilizers, synthetic growth regulators, chemicals for plant protection, etc.), new high yield genotypes that are able to provide excess food/feed, i.e., more calories for humans and livestock. All mentioned is part of Production Paradigm, consequently impaired environment through soil fertility devastation, erosion, acidification, salinization, desertification, air pollution (emission of greenhouse gasses (GHG) and other volatile pollutants), water contamination with residues of mineral fertilizers and

pesticides [1]. In parallel, the pandemic of various chronic diseases and hidden malnutrition has upraised.

Nowadays, food security is not a question of food scarcity but rather food inability to meet the nutritional requirements of humans and livestock on a daily basis. It is mainly connected to the inadequate protein level, insufficient content of vitamins, micro- and trace elements. Such a situation will culminate due to the prediction, up to the 2050, with lack of supplies of phosphate rock, as the main source of P in fertilizers [2]. What is a more important, great P quantity, from the plant based sources, is captivated in the phytate that is indigestible for humans and non-ruminants.

From this standpoint, it is of particular importance to set a new paradigm that will enable the production of nutrient dense food, able to meet not only necessary macro-nutrients quantities but rather micro-nutrients based on daily requirements.

SOIL AS A BASIC SOURCE

Agricultural plants aimed to be consumed as fresh or processed food are primarily growing on soils, which are more or less fertile. The accumulation of mineral elements in plant tissues is mainly limited by their supply and availability through roots [3]. Fertile soils, in combination with well-planned nutrition, are the basis for high yields of plants, including a variety of different phyto-nutrients that promote human health. On the other hand, when soils are infertile and poor in available nutrients, a cascade of deficiency occurs, from plants, livestock to humans. The link between Zn deficiency in humans and low Zn availability from soils is well-known [4,5]. Response of individual plants to resource availability has the conceptual model of the 'Law of the Minimum', where overall plant growth is limited by the single most limiting resource [6]. Also, increased concentration of some factors, such as commonly present P from over-fertilization of soils, can also induce Zn deficiency.

Some soil characteristics, such as concretion, poor drainage, shallowness, poor water retention, acidity, alkalinity, salinity, iron toxicity and sub-optimal availability of mineral nutrients, could induce stress to plants. Most of the soils worldwide are poor in available essential elements and/or high in toxic ions. Thus, most terrestrial vegetation grow on weathered soils that are low in P and Ca, but include Al and Mn toxicity. Soil acidity affects 4 billion ha, representing 30% of the total world ice-free land area, limiting plant growth and yield stability worldwide [7]. On the other hand, soil alkalinity is mainly connected to arid and semi-arid regions, covering more than 30% of the terrestrial areas [8], whereat alkaline salts inhibit the absorption of anions and induce poor availability of P, Fe, Cu, Mn, and Zn, as well as the increased accumulation of organic acids [9]. Certain soils have excessive amounts of heavy metals (Pb, Cd, Cu, Zn, Mn), due to soil parent material or industrial pollution. Cultivated plants could accumulate them without disrupting metabolism (lower concentrations), becoming contaminants of the food chain with heavy metals [10].

Human activity significantly contributes to soil degradation. Great areas in developing countries are degraded (65% in Africa, 50% in Latin America, and 40% in Asia) [11], where soil erosion is mainly intensified by deforestation in tropic regions, and acid precipitation accelerates soil leaching, seriously affecting European forests. Improper fertilizer policies contributed to soil acidification, while irresponsible irrigation has created serious salinity problems in semi-arid regions. Besides, high inputs of macro-nutrient fertilizers (containing N, K, P, S, Ca and Mg) and amelioration measures (including lime, gypsum, organic matter, etc.) could affect soil fertility.

CLIMATIC FACTORS AS A SOURCE OF FOOD INSECURITY

Industrialization affected not just the economy and food production but the whole planet. According to Gowdy [12], industrial civilization, developed on fossil fuels which started at the early XX century, changed the human life and accelerated the economy to a completely new level. At the same time, it contributed greatly to climate change, indicating that up to 2100 planet atmosphere could warm by 3-4 °C, and even as much as 8 °C or more. Consequently, agricultural production will not be applicable, and food security will be the most important topic of humankind. From the early decades of XXI century [13] it was estimated that agriculture, mainly food production, is contributing to total anthropogenic emissions by 10-12%, including ¼ of the continuing increase of GHG emissions, such as carbon dioxide, methane and nitrous oxide.

Climate changes include: regional variations in temperature and rainfall, extreme meteorological events, what affects distribution, phenology and abundance of some plant species, including pathogen attack (pests and diseases incidence), increased need for irrigation, yield stagnation [14]. Staple crops are particularly affected by climate change, thus it is forecasted that the lifecycle of winter wheat will be extended, while lifecycle of maize and soybean will be shortened. It was predicted that the occurrence of some pests and diseases will have greater prevalence. Soil fertility will be more devised through organic matter reduction and erosion.

ADVANCES OF AGRICULTURAL SUSTAINABILITY

In regard toindustrial agriculture, the paradigm of sustainability is based on high productivity, including preservation and/or improvement of the environment as a resource base of agriculture. The newly developed, the regenerative concept goes a step further, it implies all disposable resources to restore and improve deprived and desertificated areas. When regenerative maize production is considered, achieved grain yields were 29% lower in regard to conventional (industrial) agriculture, while the profits, which highly and positively correlated with soil organic matter, were 78% higher [15]. A sustainable model facilitates food security, based on crop diversification, crops rich in vitamins and minerals, having ability to combat malnutrition [6,16]. This means that strong bonds between nutrition, the health sector and agriculture must be provided.

Sustainable agricultural systems include various practices to achieve existing goals. One of the basic practices is soil tillage. While advantages of conservation tillage are reflecting on soil non-disturbance, problems of weed control and crop nutrition are present [17]. They could be successfully managed by involving of inter- and cover crops between two main crops in rotation. They could protect soil from erosion and nutrient losses, thus contributing to water quality, also reducing pests and weedines to some extent [18,19,20,21,22,23]. Facilitating long-term soil fertility is closely tied to the diversity and quantity of soil microbiota, which could enrich the soil with atmospheric N by fixation, increase the availability of mineral nutrients, including P, from insoluble forms [24,25,26]. This type of production mainly exploits crop varieties and hybrids that are adaptable to various environments, and also able to improve nutritional value of food [27,28], with greater efficiency in mineral nutrients uptake and accumulation, high tolerance to different abiotic and biotic stressors.

While industrial agriculture is one of the important contributors to climate change, sustainable agriculture could serve as a mitigation and adaptive solution [29]. For instance, practices commonly used on small-scale farms consume less energy and release a smaller amount of GHGs than industrial agriculture [13]. Some newly developed programs, such as ‘climate-smart agriculture’ (CSA) [30] combine ecological and economic systems to restore agricultural sources and provide long-term food security.

SUSTAINABLE FOOD AND AGRICULTURAL SYSTEMS - NUTRIENT DIVESITY

In light of worldwide present nutritional deficiencies, which affect more than 50% of the human population, causing various chronic diseases, such as cancer, cardio-vascular diseases, stroke, diabetes, osteoporosis, etc. [6,31,32] it is important that food, i.e. agricultural products are nutrient dense, able to provide optimal requirements in all essential nutrients to humans and animals. Agricultural products rich in numerous nutrients: minerals, vitamins, antioxidants, fibre, secondary metabolites and other physiologically active compounds, are able to maintain optimal health and wellbeing in humans, to increase immunity, slow down the aging process, to accelerate recovery from illnesses. The sustainable and particularly regenerative system enables the production of nutrient dense agricultural products, and at the same time to supports the environment and biodiversity [15].

Previously mentioned, rising problem with P deficiency in agro-ecosystem requires a multi-strategic approach, including changes in the food system, based on reduction of protein from animal sources, reduction in devastation from livestock and food production, as well as food losses. Agriculture has key role and it includes crop residue incorporation, perennials cropping, cover crops, improved irrigation and tillage practices, well-established crop rotations, urban gardening, combined incorporation of crop residues and manure, coordination between animal and crop production systems [21,22,33,34].

One of the rational systems that support the production of nutrient-dense food is bio-fortification, which applies various practices, sustainable and integrative, as well as conventional plant breeding or genetic engineering, to increase the concentration of essential nutrients and to decrease concentration of antinutrients in edible parts of plants with aim to combat malnutrition, globally [35,36,37,38,39].

Nevertheless, sustainable agricultural practices could have limited effect if nutrition is not diverse, including whole-grain staples and many unutilized and forgotten crops, which are an important source of vitamins, micronutrients and protein, such as buckwheat, quinoa, amaranth, drumstick tree, pulses like, vigna, mungbean and many other crops [40]. One of the strategies that provided positive results on relationship with food is urban permaculture, due to the fact that half the world's population lives in cities where growing of agricultural plants increase bio-diversity, giving totally new view on urban environments [41].

CONCLUSION

The necessity to manage the food and farming systems resulted in the development of sustainable and regenerative practices, aimed to manage soil recovery, through the increase of soil organic matter, diversity of soil microbiota and other organisms, as a part of agro-ecosystem balance, thus contributing to the increased productivity and food quality. One of the important strategies is based on the postulate “produce locally – eat locally model”, what in the combination of whole food consumption gives particular importance to small-scale producers as part of markets of agricultural products. From this viewpoint, the close connection between sustainable food systems (nutrition) and agriculture has an important role in the health enhancement of humankind and the agro-ecosystem.

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