

Towards Sustainable Organic Farming Systems

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Abstract: The European Union green deal has proposed the “organic farming action plan” to render this farming system more sustainable for climate mitigation and adaptation and to meet the United Nations Sustainable Development Goals (UN-SDGs). While this policy instrument is fundamental to reach sustainable agriculture, there is still no agreement on what sustainable agriculture is and how to measure it. This opinion paper proposes an ecosystem-based framework on the crop life-cycle to determine the balance between economic, social, and environmental pillars of sustainability to support decision-making.

Keywords: organic farming; sustainable agriculture; ecosystem services; life cycle assessment; EU Green Deal

1. Introduction

Today an emergent and consolidated quantitative literature is withstanding *i*) the environmental ineffectiveness of organic farming [1,2], *ii*) the socio-economic inefficiency [3], and *iii*) the disputed ethical correctness that can vary from the consumer's side to the producer's side and according to the case study and to the subject [4]. Advocates of this practice – as a holistic practice that shores up the interrelationship between farm biota, its production, and the overall environment – are increasingly criticised over its agricultural sustainability.

The “organic farming action plan” proposed by the European Commission under the EU Green Deal (https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en), for the development of European organic production, is an ambitious proposal to transform organic farming to a more sustainable farming practice that respects the balance between the three central pillars of sustainable development: economy, society, and environment. Reaching the objectives will be possible, according to the plan, through investment and innovation in sustainable farming.

This policy intervention towards the sustainability of organic agriculture that has been requested by Eyhorn et al. [5] is fundamental. I agree with the authors, and I share with the commission the concern and the determination to transform organic farming to a sustainable practice, to further *i*) improve the well-being of farmers, *ii*) reduce environmental burdens, and *iii*) increase the market supply to ensure a fair market price (Pareto optimal) and make organic products available for all and not only “food for the rich.”

However, policy instruments need the correct tools and methods for implementation and evaluation, and to date, there is no agreement on what sustainable agriculture is and how it is quantified [6]. How can “raising legal requirements and industry norms” or “supporting organic systems to improve their performances” suggested by Eyhorn et al. [5] for more sustainable products be possible in the absence of tools to quantify the sustainability of a product?

The following paragraphs will describe two cases of nutritional elements banned in organic farming, whose use under certain conditions could improve performances of organic systems and reduce pressure on resources. Based on this knowledge, a conceptual framework is proposed to quantify, through a scientific and consolidated method, sustainability of organic farming.

2. Phosphorus Use

According to the scientific literature and the European Sustainable Phosphorus Platform (ESPP), phosphorus (P) is essential for food security and agriculture. Still, it is a non-renewable resource, and phosphorus reserves are getting depleted [7]. At the same time, phosphorus losses pose major environmental issues; its use in agriculture as a fertiliser is the principal contributor to eutrophication and surface water quality deterioration [8].

Sustainable management of phosphorus reserves is the key to tackle these issues. Sustainable management should not be exclusively associated with environmental pollution. It requires transdisciplinary processes so that fundamental factors such as food security, resource depletion, governance, and innovation can be included. [9,10].

Phosphate rock, in its natural state, is allowed in organic farming. However, in this state, phosphorus is not available to the crop, and the quantities applied would participate completely in the eutrophication process. Ditta et al. [11] suggest organic matter and phosphate solubilising microorganisms (PSMs) be incorporated to increase the P content in crops between 4.3 and 12.9%, which is still a significant loss of phosphorus in the natural ecosystems. Yet, studies in the field have demonstrated that superphosphate (a soluble P form obtained by acidifying rock phosphates with sulphuric or phosphoric acid), at the same level of P fertilisation, has a higher P-use efficiency than the natural rock phosphate [12–14], with variable efficiency levels according to soil acidity. Furthermore, organically complexed superphosphate (CSP) is a new type of phosphate that has demonstrated a potential to significantly inhibit phosphorus fixation in soils, increasing its efficiency in different soil types with diverse physicochemical features [15,16]. However, these efficient forms of phosphorus are banned in organic farming.

3. Calcium Use

Calcium (Ca) is an essential plant nutrient, crucial for all crops with different concentrations according to variety, soil type, application type, and timing. Despite the abundance of calcium in soils, some plant varieties (calcicole species), which require high concentrations of intracellular calcium compared to other calcifuge crops, could suffer from a range of calcium-deficiency disorders that affect tissues or organs that are naturally low in calcium [17]. These include the bitter pit of apples, the blossom end rot (BER) of watermelons, peppers, and tomatoes, internal rust spots in potato tubers and carrot roots, tipburn in lettuce and strawberries, blackheart of celery, internal browning of Brussels sprouts, and internal browning of pineapple. The FAO [18] have reported that food losses occur mostly at production and post-harvest levels and could comprise 47% of the total food wastage in Europe. Calcium-related deficiencies on calcicole crops (e.g., leafy vegetables, Solanaceae vegetables, apples, and strawberries) could generate up to 50% of the yield losses [19]. Therefore, application timing and the type of calcium are crucial to overcoming this physiological barrier and reducing food losses generated from calcium-related deficiencies.

According to the literature, the ionic exchange of calcium at the physiological level is responsible for this deficiency, excluding any physical calcium deficiency in soils. For this reason, symptoms are observed, according to White and Broadley [20], *a*) in young expanding leaves, e.g., in the tipburn of leafy vegetables, *b*) in enclosed tissues, e.g., in the brown heart of green vegetables or the blackheart of celery, or *c*) in tissues fed principally by the phloem rather than the xylem, e.g., in blossom end rot of watermelons, peppers, and tomatoes, bitter pits of apples, and empty peanut pods.

Application timing and the type of calcium, according to the literature, improve yield quality and increase product shelflife. Indeed, Karp and Starast [21] explored the impacts of calcium foliar applications during the flowering stage of strawberries and showed that foliar calcium fertilisation during flowering could, if accompanied with the adequate mulching practice, increase first-grade fruits and reduce spoiled fruits. Furthermore, Herath et al. [22] recommended, in addition to a basal lime application on pineapples, administering a calcium application six months after plantation (during the flowering stage) to improve the post-harvest quality and the product shelflife. Moreover, Zozo et al. [23] showed that two calcium and boron sprays (the first at tillering and the second at

early bloom) improve growth, flower fertilisation, and the number of fertile tillers of wheat plants, resulting in a higher grain yield.

The organic sources of calcium retrieved from the literature for plant nutrition were homemade recipes that cannot be scaled up for use in a farm, e.g., dissolved eggshells (a recipe that requires a month of preparation and that yields approximately six litres of final spray mix using 20 eggs) and chamomile infused in boiled water at a ratio of 1:4. Alternatively, other sources of calcium in plant nutrition could be mined lime, gypsum, and/or other chemical compounds such as calcium chloride or calcium carbonate. The European Commission once consented, under specific conditions, to the use of foliar treatment with calcium chloride in the organic production of apple trees after the identification of a deficit [24] (Annex I). This consent was reversed without any scientific explanation.

4. Conceptual Framework

Thus, would using pure phosphate rock in high quantities for organic agriculture be more sustainable than using fewer amounts of superphosphate with a higher use efficiency and under specific conditions (i.e. alkaline soils)? Or would using calcium under certain growing circumstances to avoid food waste be less sustainable than banning its use in organic practice?

To answer similar questions and for decision-making, we need scientific evidence to assess the sustainability of agro-systems. The framework suggested in Figure 1 is an evolution of different research recommendations [6,25]; it integrates an ecosystem-based approach and life-cycle analysis (LCA) for a multi-criteria decision to provide an adequate assessment tool of trade-offs between generated or lost ecosystem services for sustainable agriculture. This framework can be used to determine nutrition inputs for organic farming and in other agro-systems such as conservation agriculture, biodynamic agriculture, and conventional agriculture.

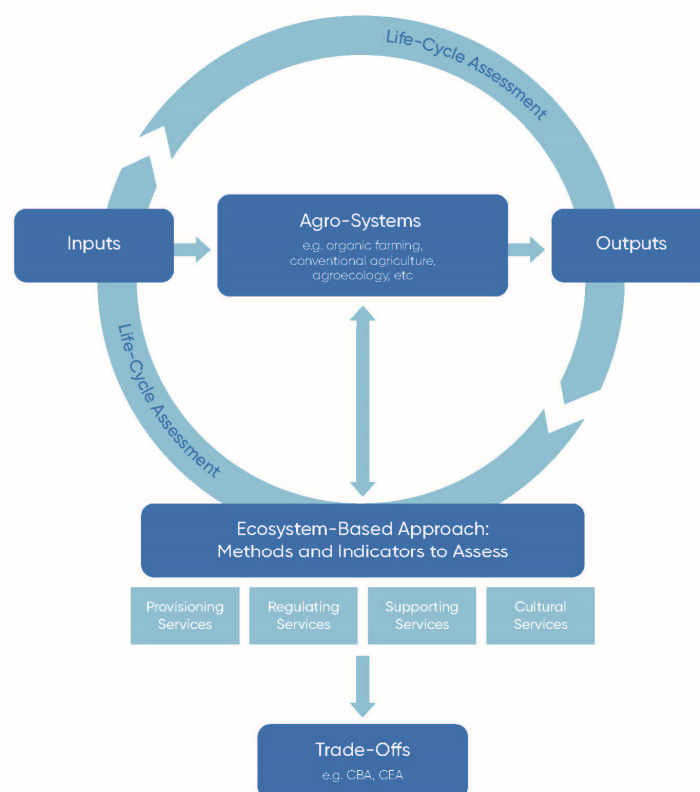


Figure 1. The conceptual framework suggested for sustainable agriculture assessment and evaluation.

LCA is a consolidated methodology abundantly applied to agricultural systems. Currently, this assessment method is undertaking continuous evolution to integrate a social impact assessment and a sustainability assessment in the so-called Sustainable Life Cycle Assessment (SLCA) and Life Cycle

Sustainability Assessment (LCSA) [26,27]. The ecosystem-based approach is still modestly used in agriculture, even though some attempts have been made [28,29]. Its integration in the latter requires the selection of ecosystem services divided into four major groups: *i*) regulating services (e.g., pollination, climate, and water regulation), *ii*) provisioning services (e.g., food and fibre), *iii*) supporting services (e.g., primary production and nutrient cycling), and *iv*) cultural services (e.g., science and education, and inspiration). It is essential to identify methods and indicators for the assessment of these ecosystem services.

Currently, methods for valuing ecosystem services are becoming more effective and more available [30]. It is crucial to select consolidated and versatile methods and indicators to cover all agro-systems regardless of the crop, the practice, and the soil and climate conditions. Once assessed, a cost-benefit analysis (CBA) or a cost-effectiveness analysis (CEA) would determine the trade-offs between different services.

This framework is the only scientific method foreseen to rigorously integrate sustainable thinking into organic farming or any other farming practice. However, this requires a complete review of the inputs list approved by the EU, with the respect of all the fundamental principles on which organic production is based: *i*) prohibition of the use of genetically modified organisms, *ii*) forbidding the use of ionising radiation, *iii*) limiting the use of artificial fertilisers, herbicides, and pesticides, and *iv*) prohibiting the use of hormones and the use of antibiotics except when necessary for animal health.

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