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Opinion Paper

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 which could vary from the consumer's 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[1] for the development of European organic production is an ambitious proposal to transform the organic farming to a more sustainable farming practice to respect 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 transforming organic farming to 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 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 to quantify it [6]. For instance, how "raising legal requirements and industry norms" or "supporting organic systems to improve their performances" suggested by Eyhorn et al. [5] for more sustainable products could 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, which their 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 in scientific and consolidated method sustainability of organic farming.

2. Phosphorus Use

According to the scientific literature and the European Sustainable Phosphorus Platform (ESPP), phosphorus 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, especially its use in agriculture as phosphorus fertilisation is the principal contributor to eutrophication and surface water quality deterioration [8].

Sustainable management of phosphorus reserves is the key to tackle all these issues together. Therefore, sustainable management should not be exclusively associated with environmental pollution, but it asks for transdisciplinary processes to include fundamental factors such as food security, resources depletion, governance, innovation, etc. [9,10].

Phosphate rock, in its natural state, is allowed in organic farming. However, on this state phosphorus is not available to the crop, and the quantities applied would completely participate in the eutrophication process. Ditta et al. [11] suggest the incorporation of organic matter and phosphate solubilising microorganisms (PSMs), to increase P content in the 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 the 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 is an essential plant nutrient, crucial for all crops with different concentrations according to the variety, soil types and 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 others 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 apple, blossom end rot (BER) of watermelon, pepper, and tomato, internal rust spot in potato tubers and carrot roots, tip burn of lettuce and strawberries, black heart of celery, internal browning of Brussels sprouts, and internal browning of pineapple.

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. This is due to the Casparian band of the endodermis which creates an effective barrier to the movement of Calcium from the phloem to be redistributed of the plant via the xylem [18]. For this reason, symptoms are observed, according to White and Broadley [19]: *a)* in young expanding leaves, such as in 'tipburn' of leafy vegetables, *(b)* in enclosed tissues, such as in 'brown heart' of green vegetables or 'black heart' of celery, or *(c)* in tissues fed principally by the phloem rather than the xylem, such as in 'blossom end rot' of watermelon, pepper and tomato fruit, 'bitter pit' of apples and 'empty pod' in peanut.

The FAO [20] have reported that food losses occur mostly at production and post-harvest levels, and they could reach 47% of the total food wastage in Europe. Calcium related deficiencies on calcicole crops (e.g. leafy vegetables, Solanaceae vegetables, apple, strawberry, etc.) could generate up to 50% of the yield losses [21]. Therefore, application timing and type of Calcium is crucial to overcome this physiological barrier and to reduce food losses generated from calcium-related deficiencies.

Application timing and type of Calcium, according to the literature, improve yields' quality as well as it participates in increasing shelf life of products. Indeed, Karp and Starast [22] experimented the impact of calcium foliar application during the flowering stage of strawberry, and the authors 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. [23] have recommended, in addition to the basal lime application on pineapple fruit, to add calcium application after six months from the plantation (during the flowering stage), to improve the post-harvest quality and shelf life of the products. Moreover, Zozo et al. [24] showed that two calcium and boron sprays (the first one at tillering and the second at early bloom), improves growth, fertilisation of flowers and the number of fertile tillers of wheat plants resulting in higher grain yield.

The organic sources of Calcium retrieved from the literature for plant nutrition are homemade recipes which could not be scaled-up for use at a farm level, i.e. dissolved eggshells (a recipe that requires a month of preparation and 20 eggs would approximately make 6 litres of final mix to spray), or chamomile infusion in boiled water at a rate of 1:4. Alternatively, other sources of Calcium in plant nutrition could be mined lime and/or gypsum and other chemical compounds such as calcium chloride or calcium carbonate. In the past, the European Commission has consented, under specific conditions, the use of foliar treatment with calcium chloride in organic production of apple trees after identification of deficit [25 – Annex I]. This consent has been lifted again without any scientific explanation.

4. Conceptual Framework

So, using pure phosphate rock in high quantities for organic agriculture would be more sustainable than using fewer amounts of superphosphate with higher use efficiency and under specific conditions (i.e. alkaline soils)? Or using Calcium under certain growing circumstances to avoid food waste would be less sustainable than banning its use under 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 [6,26], and it integrates an ecosystem-based approach and life-cycle analysis for a multi-criteria decision to provide an effective assessment tool of trade-offs between generated or lost ecosystem services, for sustainable agriculture. This framework can be applied to determine nutrition inputs for organic farming as much as it could be extended to other agro-systems such as conservation agriculture, biodynamic agriculture, conventional agriculture, etc.

This framework is the only foreseen scientific method 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 EU organics rules, with the respect of all the fundamental principles on which organic production is based: *i)* prohibition of the use of GMOs; *ii)* forbidding the use of ionising radiation; *iii)* limiting the use of artificial fertilisers, herbicides and pesticides; *iv)* prohibiting the use of hormones and restrict the use of antibiotics and only when necessary for animal health.

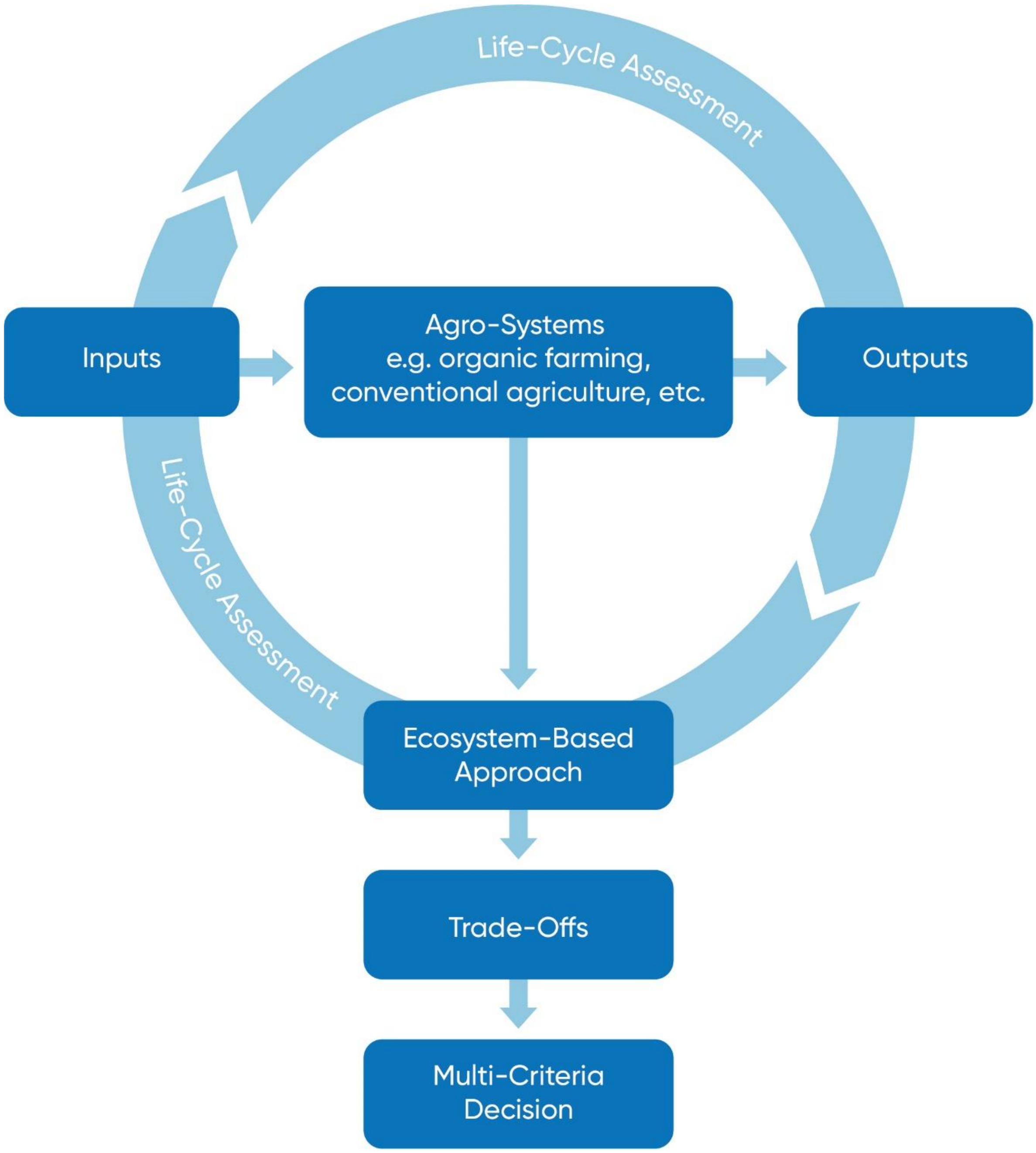

Figure 1. The conceptual framework suggested for sustainable agriculture assessment and evaluation.

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References

1. Searchinger, T.D.; Wirsenius, S.; Beringer, T.; Dumas, P. Assessing the efficiency of changes in land use for mitigating climate change. *Nature* **2018**, *564 (7735)*: 249. doi: 10.1038/s41586-018-0757-z
2. Leifeld, J. How sustainable is organic farming? *Agr. Ecosyst. Environ.* **2012**, *150*: 121-122. doi: 10.1016/j.agee.2012.01.020

3. Qiao, Y.; Halberg, N.; Vaheesan, S.; Scott, S. Assessing the social and economic benefits of organic and fair trade tea production for small-scale farmers in Asia: a comparative case study of China and Sri Lanka. Renew. *Agr. Food Syst.* **2016**, *31 (3)*: 246-257 doi: 10.1017/S1742170515000162
4. Padel, S.; Nicholas, P. Jasinska, A.; Lampkin, N. Ethical concerns associated with organic food in Europe. *In: 16th IFOAM Organic World Congress (OWC)*. 16-20 June 2008, Modena, Italy.
5. Eyhorn, F.; Muller, A.; Reganold, J.P.; Frison, E.; Herren, H.R.; Mueller, A.; Sanders, J.; El-Hage Scialabba, N.; Seufert, V.; Smith, P. Luttikholt, L. Sustainability in global agriculture driven by organic farming. *Nature Sustainability* **2019**, *2*: 253-255. doi:10.1038/s41893-019-0266-6
6. El Chami, D.; Daccache, A.; El Moujabber, M. How can sustainable agriculture increase climate resilience? A systematic review. *Sustainability (Basel)* **2020**, *12 (8)*: 3119. doi:10.3390/su12083119
7. Daneshgar, S.; Callegari, A.; Capodaglio, A.G.; Vaccari, D. The Potential Phosphorus Crisis: Resource Conservation and Possible Escape Technologies: A Review. *Resources (Basel)* **2018**, *7 (2)*: 37. doi:10.3390/resources7020037
8. Carpenter, S.R. Eutrophication of aquatic ecosystems: Bistability and soil phosphorus. *PNAS* **2005**, *102 (29)*: 10002-10005. doi: 10.1073pnas.0503959102
9. Scholz, R.W.; Ulrich, A.E.; Eilittä, M.; Roy, A. Sustainable use of phosphorus: A finite resource. *Sci. Total Environ.* **2013**, *461-462*: 799-803. doi:10.1016/j.scitotenv.2013.05.043
10. Schröder, J.J.; Cordell, D.; Smit, A.L.; Rosemarin A. *Sustainable use of phosphorus*. EU Tender Env.B.1./ETU/2009/0025, Report 357 (2010).
11. Ditta, A.; Muhammad, J.; Imtiaz, M.; Mehmood, S.; Qian, Z.; Tu, S. Application of rock phosphate enriched composts increases nodulation, growth and yield of chickpea. *Int. J. Recycl. Org. Waste Agricult.* **2018**, *7*: 33-40. doi:10.1007/s40093-017-0187-1
12. Lukiwati, D.R. (2002) Effect of rock phosphate and superphosphate fertiliser on the productivity of maise var. Bisma. *In: Adu-Gyamfi, J.J. (Eds), Food Security in Nutrient-Stressed Environments: Exploiting Plants' Genetic Capabilities*. Developments in Plant and Soil Sciences, vol 95. Springer, Dordrecht (2002): 183-187. doi:10.1007/978-94-017-1570-6_20
13. Mallarino, A.P.; Rueber, D. Evaluation of Superphosphate and Rock Phosphate for a Corn-Oat-Forage Rotation. *In: Northern Research and Demonstration Farm, Annual Progress Reports, ISRF97-22*. Iowa State University, Ames (IA), USA (1997): 6-8.
14. Choudhary, M.; Peck, T.R.; Paul, L.E.; Bailey, L.D. Long-term comparison of rock phosphate with superphosphate on crop yield in two cereal-legume rotations. *Can. J. Plant Sci.* **1994**, *74 (2)*: 303-310. doi:10.4141/cjps94-058
15. Giovannini, C.; Garcia-Mina, J.M.; Ciavatta, C.; Marzadori, C. Effect of organic-complexed superphosphates on microbial biomass and microbial activity of soil. *Biol Fertil Soils* **2013**, *49*: 395-401. doi: 10.1007/s00374-012-0731-0
16. Erro, J.; Urrutia, O.; Baigorri, R.; Aparicio-Tejo, P.; Irigoyen, I.; Torino, F.; Mandado, M.; Yvin, J.C.; Garcia-Mina, J.M. Organic complexed superphosphates (CSP): Physicochemical characterisation and agronomical properties. *J. Agric. Food Chem.* **2012**, *60*: 2008-2017. doi: 10.1021/jf204821j
17. Pilbeam, D.J.; Morley, P.S. Chapter 5 – Calcium. *In: Barker AV and Pilbeam DJ (Eds.), Handbook of Plant Nutrition*. Taylor & Francis Group, LLC. (2007): 121-144.
18. Clarkson, D.T. Calcium transport between tissues and its distribution in the plant. *Plant, Cell & Environment* **1984**, *7 (6)*: 449-456. doi:10.1111/j.1365-3040.1984.tb01435.x
19. White, P.J.; Broadley, M.R. Calcium in plants. *Ann. Bot.-London* **2003**, *92 (4)*: 487-511. doi:10.1093/aob/mcg164
20. FAO. *Food wastage footprint, impacts on natural resources – Summary report*. Food and Agriculture Organization of the United Nations (FAO) (2013). 61 p.
21. Taylor, M.D.; Locascio, S.J. Blossom-End Rot: A Calcium Deficiency. *J. Plant Nutr.* **2004**, *27 (1)*: 123-139. doi:10.1081/PLN-120027551
22. Karp, K.; Starast, M. Effects of springtime foliar fertilisation on strawberry yield in Estonia. *Acta Hortic.* **2002**, *594*: 501-505. doi:10.17660/ActaHortic.2002.594.65
23. Herath, H.M.I.; Bandara, D.C.; Abeysinghe Banda, D.M.G. Effect of pre-harvest calcium fertiliser application on the control of internal browning development during the cold storage of pineapple 'Mauritius' (Ananas comosus (L.) Merr.). *J. Hort. Sci. Biotech.* **2003**, *78 (6)*: 762-767. doi:10.1080/14620316.2003.11511696

 doi:10.20944/preprints202011.0476.v1

24. Zoz, T.T.; Steiner, F.; Seidel, E.P.; Castagnara, D.D.; de Souza, G.E. Foliar application of Calcium and boron improves the spike fertility and yield of wheat. *Biosci. J.* **2016**, *32 (4)*: 873-880.
25. EC. *Laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control*. Commission Regulation (EC) No 889/2008 (2008). 84 p.
26. El Chami, D.; Daccache, A. Assessing sustainability of winter wheat production under climate change scenarios in a humid climate – An integrated modelling framework. *Agr. Syst.* **2015**, *140*: 19-25 doi: 10.1016/j.agsy.2015.08.008