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Article *in* Environment Biodiversity and Soil Security · July 2022

DOI: 10.21608/JENVBS.2022.145977.1180

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Env. Biodiv. Soil Security, **Vol. 6**, pp: 149 - 163 (2022)

Environment, Biodiversity & Soil Security

http://jenvbs.journals.ekb.eg/

From Farm-to-Fork: A pictorial Mini Review on Nano-Farming of Vegetables

Zakaria F. Fawzy [1] Hassan El-Ramady [2,5], Alaa El-Dein Omara [3], Tamer Elsakhawy [3], Yousry Bayoumi[4], Tarek A. Shalaby[4] and József Prokisch [5]

[1] *Vegetable Crops Dept., Agriculture and Biological Research Institute, National Research Centre, 33 El-Behouth, Dokki, 12622 Giza, Egypt*
[2] *Soil and Water Dept., Faculty of Agriculture, Kafrelsheikh University, 33516 Kafr El-Sheikh, Egypt*
[3] *Agriculture Microbiology Department, Soil, Water and Environment Research Institute (SWERI), Sakha Agricultural Research Station, Agriculture Research Center, 33717 Kafr El-Sheikh, Egypt*
[4] *Horticulture Department, Faculty of Agriculture, Kafrelsheikh University, 33516 Kafr El-Sheikh, Egypt*
[5] *Institute of Animal Science, Biotechnology and Nature Conservation, Faculty of Agricultural and Food Sciences and Environmental Management, University of Debrecen, 138 Böszörményi Street, 4032 Debrecen, Hungary*

As a backbone of any nation, agriculture is the main supplier for our needed from food, feed, fiber and fuel. The production of vegetables is one of the main pillars of the agricultural production for human nutrition. This production nowadays has a serious problem, which may lead to many problems for human health. So, the “from farm to fork or F2F” initiative was launched last 2020 for healthy and eco-friendly food system. This study is a photographic mini-review on the strategy of F2F and the importance to produce healthy food like edible vegetables. The main targets of this strategy may include preventing food loss and waste, sustaining the production, and processing of food, its distribution, and consumption. The nano-farming expresses on using different nanomaterials in different agricultural practices of vegetables like nano-priming, nanofertilizers, nano-pesticides, nano-harvesting, and nano-postharvest. The current work was designed to answer about the main question: can nano-farming support the F2F strategy? More open questions will be presented in this review.

Keywords: Smart agriculture, Nanoparticles, Sustainability, Healthy food, The F2F-strategy.

1. Introduction

Human needs several life necessaries including healthy food, clear water, clean air, suitable raw materials for producing fibers and fuel. Due to the intensive and unfair human activities and industrialization, several places all over the world started to search about the sustainable solution for this health food and water like the European union (EU). The European Commission in EU called for European Green Initiative from the 3F strategy “From Farm-to-Fork” (EC 2022). What does the “Farm to Fork strategy” mean? It means how to produce a food from a fair, healthy and environmentally-friendly food system (EC 2022). Can we make the global food system healthier and sustainable? The answer definitely depends on the

*Corresponding author e-mail: ramady2000@gmail.com
Received: 20/06/2022; Accepted: 03/07/2022
DOI: 10.21608/JENVBS.2022.145977.1180

environmental conditions, which may allow to produce the healthy and sustainable food as reported by many studies such as "Farm to fork strategy" under the problems of pathogens at slaughter (Castro et al. 2022), relationship between carbon productivity and farm profitability (Coderoni and Vanino 2022), restrictions of F2F strategy by reducing the use of fertilizers and pesticides in agriculture (Cortignani et al. 2022), and the role of smart farming under using digitalization for farm to fork (Donaldson 2022).

Nanoparticles or nanomaterials are very common in our life before the human existence. The most common nanoparticles in the nature are clay particles, which have the colloidal properties as well. Nowadays, nano-agriculture has penetrated different branches of agriculture including plant nutrition (El-Ramady et al. 2018; Rajput et al. 2022), nano-enabled agriculture (Wu and Li 2022), nanofertilizers (Ibrahim and Hegab 2022; Shalaby et al. 2022), nano-pesticides (Dangi and Verma 2021; Raj et al. 2021; Singh et al. 2022), nano-sensors or nano-biosensors (Saravanakumar et al. 2022), nano-food industries (Muthukrishnan 2022), nano-remediation of soil and water (Fei et al. 2022), nanoparticles/nanomaterials for ameliorating stress on cultivated plants (Ghosh et al. 2022), nano-biofortification for human health (El-Ramady et al. 2021a, b), nano-farming (Behl et al. 2022), and for sustainable agriculture (Hazarika et al. 2022). Recently, many photographic reviews or mini-reviews have been published such as about smart farming (Fawzy and El-Ramady 2022), soil and humans (El-Ramady et al. 2022), management of salt-affected soils (El-Ramady et al. 2022b), a comparative review on higher plants and mushrooms (El-Ramady et al. 2022c).

Therefore, this mini-review discusses the possibility to produce healthy and sustainable food using the strategy of from farm-to-fork. This photographic study involved also the applications of nanotechnology in the production of vegetables including nano-priming, nano-fertilization, nano-pesticides, etc. The answer of the main question in this work is can nano-farming support the achieving of the 3F-stategy?

2. The 3F-strategy "From Farm-to-Fork"

What is the F2F or 3F or "*From Farm-to-Fork*" strategy? As a part of the European Green Deal, this strategy was launched on 20 May 2020. It is "*a comprehensive 10-year strategy aiming to address the challenges of producing and consuming our food in a fair and sustainable way by reconciling what we eat within the capacity of our planet*" (EC 2020). Several environmental and climate impacts are needed to be reduced by following this strategy to ensure food security and citizens' health (EUFIC 2022). The question is now: how does the F2F strategy work? This strategy has mainly 5 targets including (1) ensuring sustainable food production and its security, (2) reducing food loss and waste, (3) promoting sustainable food consumption and facilitating the shift to sustainable, and healthy diets, (4) stimulating sustainable food processing, wholesale, retail, hospitality, and food services practices, and (5) combating food fraud along the food supply chain (EC 2020), as collected in **Fig. 1**. **Figure 2** shows some steps belonging the production of food (an example of carrots) processing, packing, handling, and delivering for consumption.

This year (2022), many other reports have published concerning this strategy to focus on more topics related to the F2F strategy (**Table 1**) such as the role of terrestrial and aquatic farm viruses in food production systems under F2F strategy (Mahony and van Sinderen 2022), using the biofortification of tomato with carotenoid as a sustainable strategy for the agro-food chain (Meng et al. 2022), reducing food wastes at the level of food service, retail, and the household levels by understanding and addressing food wastes from date labeling of the products (Patra et al. 2022), using some innovative urban farming techniques as an example for sustainability of "F2F" in the cities (Shehata et al. 2022), scenarios of achieving the "F2F" 50% pesticide reduction for avoiding environmental and human health risks (Silva et al. 2022), and reducing applied pesticide amounts more than 60% based on canopy characteristics in apple trees to reduce environmental risks (Xun et al. 2022).

Fig. 1: The strategy sets out both regulatory and non-regulatory initiatives, with the common agricultural and fisheries policies as key tools to support a just transition. https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en accessed on 16.6.2022.

Fig. 2. The production of vegetables should follow many steps to be ready to consumption starting with producing the vegetables in the field, delivering the fruits (upper photos) to the factory for cleaning, sorting and packing (middle photos) in suitable packages and transportation (lower photos). Collecting different fruits like carrots, preparing, and transporting to be ready for shopping in Italy. All photos by Zakaria.

Table 1. A survey on most important published articles on from farm-to-fork this year (2022).

The main title or topic of the published article	References
The impacts of super-shedders and high-event periods under "Farm to fork strategy" on food safety and mainly contamination with pathogens at slaughter	Castro et al. (2022)
Strong relationship between carbon productivity and farm profitability; based on the relation between carbon productivity and agro-economic performance at the farm level	Coderoni and Vanino (2022)
Farm to Fork strategy (i.e., F2F target) has many restrictions by reducing the use of fertilizers and pesticides as chemical inputs in farming in Italy	Cortignani et al. (2022)
The role of smart farming in agriculture digitalization and food production using digital from farm to fork in infrastructures of quality and control in food supply chains	Donaldson (2022)
The role of terrestrial and aquatic farm viromes (viruses) in food production systems and their importance for 'farm to fork' analyses	Mahony and van Sinderen D (2022)
Using the biofortification of tomato with carotenoid as a sustainable strategy for the agro-food chain from field to fork	Meng et al. (2022)
Reducing food waste at retail, food service, and the household levels by understanding and addressing food wastes from date labeling of the products	Patra et al. (2022)
Using some innovative urban farming techniques in the city of Lanuvio (Rome, Italy) as an example for Sustainability of "Farm to Fork" in the cities	Shehata et al. (2022)
Certain scenarios to achieve the "Farm to Fork" 50% pesticide reduction by strong restrictions are needed to avoid risks to environmental and human health	Silva et al. (2022)
Reducing the applied pesticide amount based on canopy characteristics in apple trees by more than 60% to reduce environmental risks	Xun et al. (2022)

3. Nano-farming of vegetables

The production of different horticultural crops is very important for human diets, which include the vegetables, fruits, and medicinal plants. Vegetable crops are rich in minerals, vitamins, and many bioactive compounds. The vegetables production has a certain approach, which need in general to produce the seedlings for almost vegetable crops in nurseries (**Fig. 3**), in open field and under greenhouses (**Fig. 4**), even under normal non-saline or saline soils. Recently, a closed system for vegetable and fish production was created. This system can use gravels or hydroponics as growing media and the drained water could be collected and inserted in fish pool for production fish, and the water in fish farming can be re-oriented (as a rich in ammonia) again to the vegetables like tomato, cucumber, cabbages, and pepper, as a source rich in N-fertilizer (**Fig. 5**).

Vegetable production, like other agricultural products, was penetrated by the applications of nanotechnology (Behl et al. 2022). The main applied nanomaterials in agriculture include the nano-chemicals such as nano-fertilizers, nano-fungicides, nano-herbicides, nano-pesticides, and nano-insecticides, as common nano-agrochemicals (Raj et al. 2021). These nanomaterials have an increased concern due to their economically viable and eco-friendly nature, as well as their enormous benefits in agriculture (Raj et al. 2021; Sharma et al. 2022). Nano-farming is expressed on the using of nanoparticles/nanomaterials in different each agricultural practice such as nano-priming of vegetable seeds (Salam et al. 2022), nanofertilizers (An et al. 2022), nano-pesticides (Abdollahdokht et al. 2022), nano-packing (Wang et al. 2020), and also postharvest or storing vegetables under vacuum ultraviolet (Mabusela et al. 2022). Nano-postharvest is nowadays common as nano-emulsion based edible coatings of vegetables to apply essential oils as bioactive compounds (Pandey et al. 2022).

Fig. 3a. In the field of vegetable production, preparing and production of transplants from the horticultural nurseries is the backbone of the field. Production of transplants can be divided into 2 stages, first is the collecting the growing media, which are not normal soil but vermiculite and peat moss as common growing materials that use in producing and papering the seedling for cultivation in green house in Bari (Italy). All photos by El-Ramady.

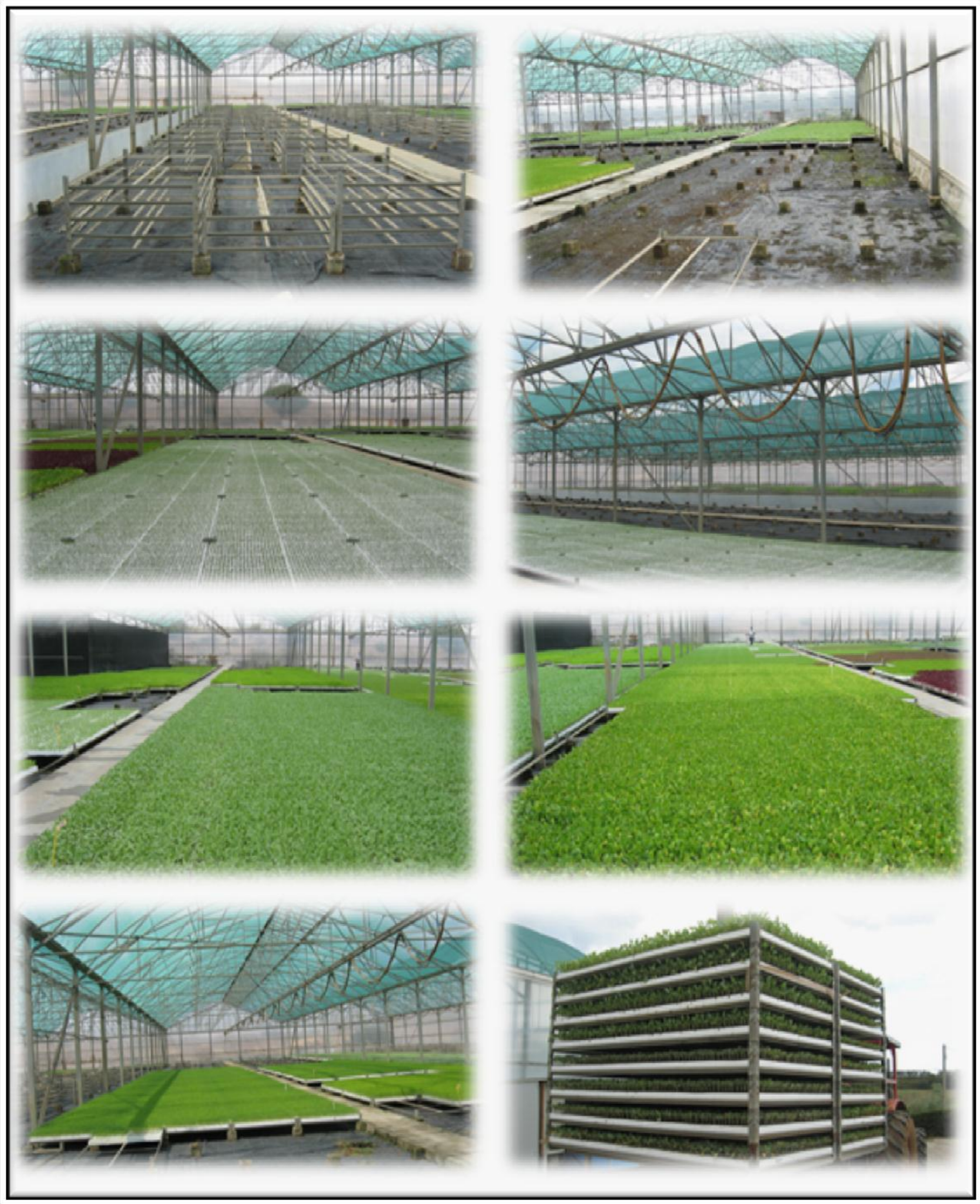

Fig. 3b. Production of transplants from the horticultural nurseries: the second stage is representing in filling the trays with growing media and put the seeds of selected crops. Production of transplants using a certain fertilization and irrigation program to produce seedlings in greenhouse in Bari (Italy) the last photo in right upper is the tractor carrying the transplanting's to move them to the open field. All photos by El-Ramady.

Fig. 4a. The intensive production of vegetables under greenhouses in Emirates. The 2 upper photos are tomato, whereas the middle photos are squash in the field of greenhouse and as packaged plates. The upper photos packages to be ready for shopping from different vegetable crops. All photos by Zakaria Fawzy.

Fig. 4b. Different vegetable crops are already cultivated in salt-affected soils under greenhouse conditions at Kafrelsheikh university, in the experimental farm, Egypt. Strawberry, green and color pepper, and cucumber are common vegetable crops cultivated in this area, as shown in photos from up to down. All photos by El-Ramady

Fig. 5. Closed system for vegetable production using gravels as growing media and the drained water is collected and insert in fish pool for production fish, and the water in fish farming is re-oriented again to the vegetables like tomato, cucumber, cabbages, pepper etc. at the experimental farm in Kafrelsheikh Uni., Egypt. All photos by El-Ramady.

For improving vegetables productivity and biosafety, nano-agrochemicals can be sued to upgrade the efficiency of agro-inputs by providing permanent solutions. Nano-agrochemicals have economic importance, which can enhance the efficiency of agro-inputs and improve food productivity and its security (Raj, et al., 2021). It could construct nano-agrochemical delivery system through nanomaterials (NMs) facilitates to improve the stability and dispersion of their active ingredients, promote the precise delivery of these agrochemicals, reduce the residual effects or expected pollution and decrease labor costs under different applied scenarios to maintain the sustainability of agricultural systems and to improve food security through increasing the efficacy of agro-inputs (An et al. 2022).

4. Nano-farming of vegetables for 3F-stategy

The production of vegetables needs certain agricultural practices starting from the germination of seeds, growth and development of cultivated vegetable plants, harvesting and postharvest processes as well. All these previous stages definitely need a special concern to achieve the 3F or F2F strategy. Nanotechnology has a great contribution to the previous practices including both pre- and post-harvesting stages as well as the vegetable food processes. For example, seed priming using nanoparticles/nanomaterials is called nano-priming, which causes a physiological change in the seed that permits it to germinate more rapidly especially under abiotic and biotic stresses as well as for forest reclamation purposes (Nile et al. 2022). Many open questions are answered in both **Figs. (6) and (7)** concerning the nano-farming of vegetables under the umbrella of from farm -to-fork strategy including:

- What does mean "Nano-Farming" and "Farm-to-Fork" or F2F Strategy?
- What is the main target of nano-farming and the F2F strategy?
- What is the main benefit of nano-farming and the F2F strategy?
- What is the link between nano-farming and farm-to-fork strategy?
- How vegetable production could be supported under nano-farming approach?
- What is the possibility to produce nano-farming vegetable under F2F strategy?
- What are the main obstacles facing production nano-farming vegetable under F2F strategy?
- What are main applications of nano-farming for vegetable production under F2F strategy?

More questions for sure are still needed to cover this very important approach, which may guarantee to produce the healthy and sustainable foods.

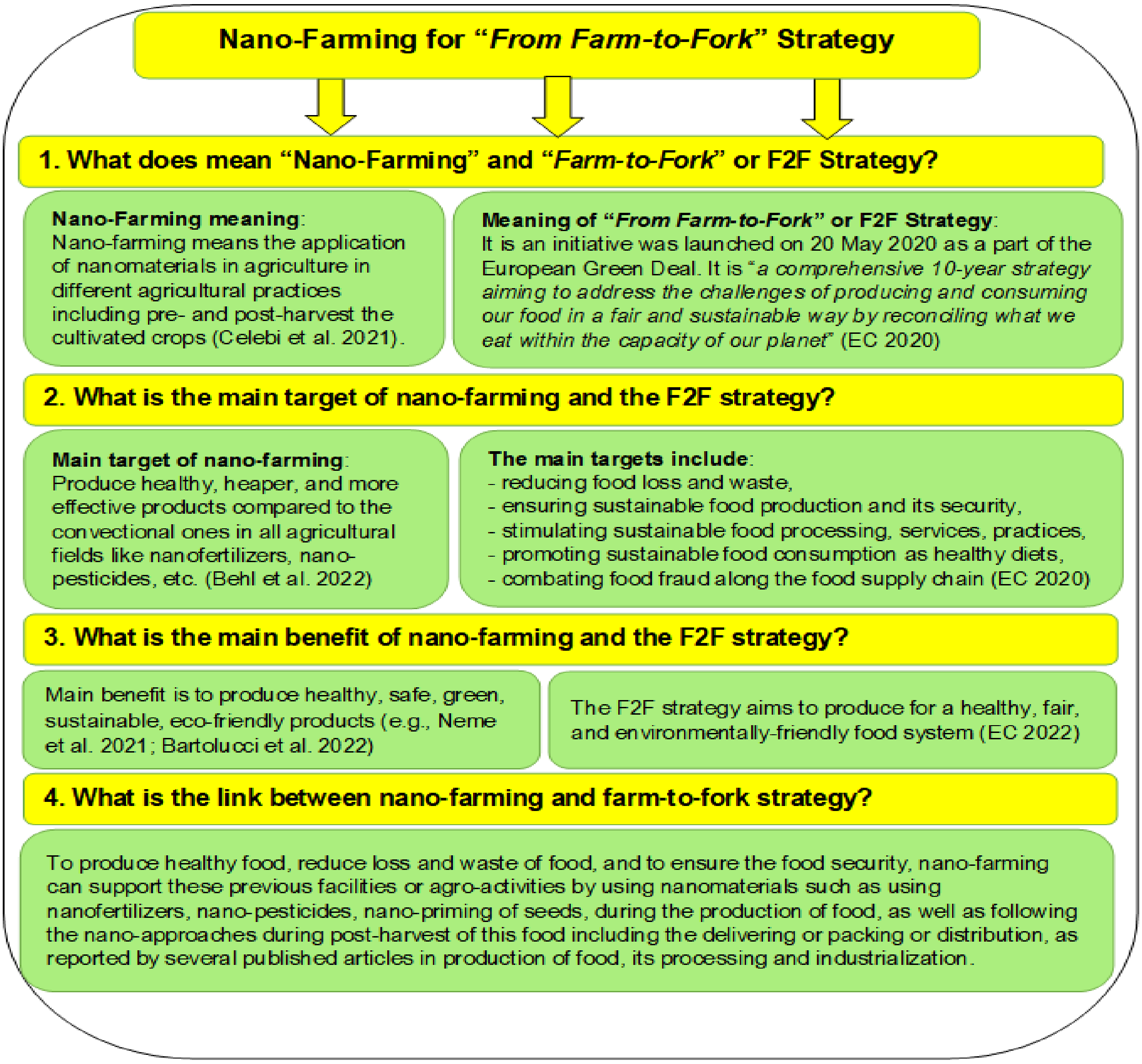

Fig. 6. What is the difference between nano-farming and the F2F strategy? The meaning, benefits, and their link between these studies items. Mentioned refs. in the drawn figure are listed in the list of refs.

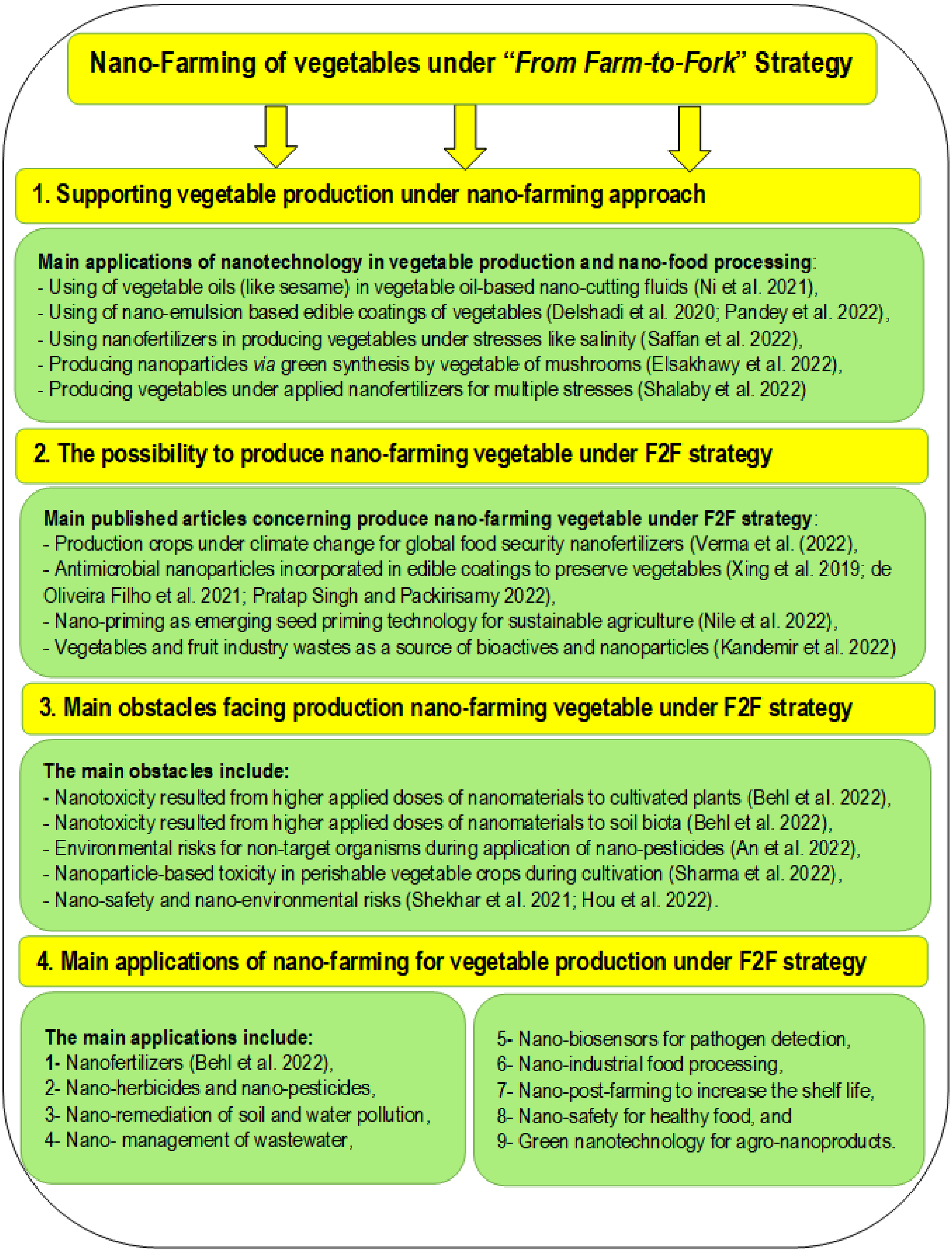

Fig. 7. Nano-farming of vegetable crops, and how this nano-formulation can support the strategy of farm to fork, including the problems and different cases belong this relationship. Mentioned refs. in the drawn figure are listed in the list of refs.

5. Conclusions

This work is a direct invitation to submit articles to the journal of Environment, Biodiversity and Soil Security (EBSS) on nano-farming under the global initiation of "from field -to- fork". This initiative strategy aims to try producing the healthy and sustainable foods especially vegetables, which the main source for human nutrition from vitamins, minerals, bioactive compounds. Several agricultural practices could be achieved through different applications of nanotechnology, which start with seed germination (using nano-priming), growth and development of cultivated vegetables using nanofertilizers and/or nano-pesticides as well as the harvesting, handle, packing, distribution and post-harvesting of vegetables. This topic still contains a lot of interesting themes, which more investigations are needed especially the photographic reviews or mini-reviews.

Ethics approval and consent to participate: This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication: All authors declare their consent for publication.

Funding: This research received funding from the Hungarian Tempus Public Foundation (TPF), grant no. AK-00152-002/2021.

Conflicts of Interest: The author declares no conflict of interest.

Contribution of Authors: All authors shared in writing, editing and revising the MS and agree to its publication.

Acknowledgments: H. El-Ramady thanks the Hungarian Tempus Public Foundation (TPF), grant no. AK-00152-002/2021 for financializing and supporting this work.

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