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Journal of Clinical and Laboratory Research
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Research Article

Significance of Microbiology in Addressing Sustainable Food Security and Nutrition (FSN) Situation

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Received Date: May 15, 2023 | **Accepted Date:** May 31, 2023 | **Published Date:** June 09, 2023

Citation: Santosh K. Mishra, (2023), Significance of Microbiology in Addressing Sustainable Food Security and Nutrition (FSN) Situation, *Journal of Clinical and Laboratory Research*. 6(2); **DOI:**10.31579/2768-0487/105

Abstract

The food security and nutrition (FSN) exist when all individuals have reliable access to sufficient quantities of affordable and nutritious food to lead a healthy life. Today, there is increased need to eradicate hunger than ever before, especially in the era of Covid-19 which has added new dimensions to already existing global food crisis. The FSN, which refers to Sustainable Development Goal (SDG)-2: Zero Hunger [End hunger, achieve food security and improved nutrition and promote sustainable agriculture], calls for accelerating efforts to increase food production in all regions of the globe. It is in this context that the agricultural scientists and food science experts are looking at microbiology-based solutions to enhance crop yield.

Microbiology (defined in simpler form as "the study of all living organisms that are too small to be visible with the naked eyes") occupies increased significance in the context of FSN. In addition, microbiological processes are vitally important to almost all stages of the food production process. The author of this research presents argument that there are four stages of FSN that are directly connected with microbiology. They are: (a) food production, (b) food processing, (c) food preservation, and (d) storage. It is known fact that microbes (such as bacteria, molds, and yeasts) are used for foods production. Also, they are employed as and food ingredients (in production of wine, and beer, including dairy products).

Today, it is being increasingly recognized that enhancing microbiological processes can have a beneficial impact on food production. They have the potential to provide the solution to the growing global problem of food insecurity. At this juncture, the author of this manuscript makes a point that with developments and innovations in the field of agriculture and crop science, microbial-based solutions for agriculture are emerging as some of the most viable solutions to the food insecurity crisis. Microbial-based solutions in the new millennium are taking roots in many several regions and continents, including the developed world. Importantly, such solutions leverage the fact that microbes influence the growth of plants and the soil in which they grow. It should be noted that plant-associated microbiomes have resulted in improvements in plant resilience and yields, including enhanced resistance to insects, and extreme weather conditions. Over and above, microbial-based solutions have been found to be "environmentally sustainable". This is because of the fact that microbial-based methods ensure improvement in crops yields while boosting the resilience of agricultural systems, thereby ensuring long-term sustainability in agricultural sector. According to some estimates, microbial-based solutions can increase crop yields by nearly 15%. From this perspective, microbiology offers a sustainable approach to enhancing food security, at all times and everywhere.

This research paper primarily aims to provide an insight into the role microbiology can play in addressing food security. It discusses the ways in which microbiology can be (and is being) used to boost the quality, quantity, and reliability of crop yields. Discussion on how microbial-based solutions will address the global issue of food security forms part of objectives of this paper. In terms of methodology, largely qualitative data have been used in the work; they are secondary in nature (collected from books, book chapters, journal articles, government publications, etc.). Method of data analysis is descriptive. Desk-based research method has been used by the author in this research. This review paper briefly concludes that microbiological processes are key considerations in all stages of the food production process. The bottom line is that enhancing microbiological processes can have a beneficial impact on overall food production; crop yield increases significantly. It may, thus, provide viable solution to the growing global problem of hunger and food insecurity situations. To sum up, microbial products have the potential to increase crop yields, including being capable to complement and (or) replace agricultural chemicals and fertilizers (which are pre-requisites for "sustainable agriculture"). Innovations and development in the field of microbiological processes has significantly benefitted crop yields.

Key words: microbiology; agriculture; zero hunger; food security and nutrition (FSN); and sustainable development goal (SDG)

1.Introduction

The study of microbes (a microorganism, especially a bacterium causing disease or fermentation) is important to the study of all living things. Microbiology (defined as: "the study of all living organisms that are too small to be visible with the naked eye") is, thus, essential for the study and understanding of all life existing on the planet. In the context of present research paper (which aims to investigate into role of microbiology in tackling food situation), the pertinent question needing answer is: can microbes help the international community in solving food crisis situation? Its answer lies in the fact that "microbes are adept at surviving and thriving in extreme and constantly changing environments". The fact remains is that a fraction of microbes is pathogenic, causing diseases. The majority of them, on the other hand, are 'beneficial' (and sometimes 'neutral') and essential for day-to-day human life [1]. With advances in science and technology, microbiology has the potential to play significant role in improving the food and nutrition situation (FSN), now and in the future. Notably, the terms 'microbes" and 'microbiology', and "microbial systems" and "microbial-based solutions" have been used interchangeably by the author in this work.

According to the American Society for Microbiology (ASM, with its headquarters at Washington, DC, USA), microbes are integral in food production system. The ASM [which hosted a virtual panel during the United Nations General Assembly (UNGA) Science Summit, discussing the role and contribution of science to the attainment of the United Nations Sustainable Development Goals (SDGs)] opines that some soil microbes aid in plant growth via their role in soil protection and fertilization. At the same time, ASM states that some other microbes are destroyers of: (a) "food spoilage"; and (b) "crops, and livestock". Significantly, other types of microbes are direct producers of food through 'fermentation' [1].

2. Methodology:

2.1 Rationale:

The World Health Organization (WHO) has identified three main aspects of food security ("food availability", "food access", and "food utilization") [2]. As global food insecurity crisis escalates in the new millennium, hope shrinks for millions already suffering from extreme hunger, especially in post-Covid pandemic era. Hunger, today, is one of the most undignified sufferings of humanity. According to some estimates, nearly a billion people across the world experience the effects of food insecurity [3].

What is worrisome is that food demand is expected to increase between 59% to 98% by the year 2050. This trend will shape the future of agricultural markets in ways not witnessed previously. What it implies is that farmers worldwide will need to increase crop production. This can be done by two ways: (a) by increasing the amount of agricultural land to grow crops, and (or) (b) by enhancing productivity on existing agricultural lands. Agricultural productivity can be increased in two ways: (1) through fertilizer and irrigation, and (2) adopting new methods like "precision agriculture" (PA). [4]. The PA defined as is an approach to farm management that uses information technology (IT) in order to ensure that both crops and soil receive exactly what they need for the purpose of optimum (soil) health and productivity. Importantly, the aim of PA method is three-fold: to ensure (1) 'profitability', (2) 'sustainability', and (3) 'protection' of the environment [5]. Increasing the amount of agricultural land does not seem to be feasible, especially when one looks at the ever-increasing volume of population. This situation adds new dimension to the already existing food crisis. Application of microbiology in agriculture finds significance in initiatives aimed at expanding crop yield.

Description presented in the introductory section of this paper is indicative of the fact that microbiological processes are vitally important in almost all stages of the food production process. Agricultural scientists, today, recognize that enhancing microbiological processes in crop farming can result in beneficial impact on food production. This, in turn, will provide the solution to the growing global problem of food insecurity and hunger. This forms the need and rationale of the present research.

2.2 Objectives:

In terms of objectives, the author of this work aims to provide an insight into the role microbiology can play in addressing food security and nutrition (FSN). It discusses the ways in which microbiology can be used to boost the quality, quantity, and reliability of crop yields. Discussion on how microbial-based solutions will address the global issue of food security forms part of objectives of this paper.

2.3 Type and Sources of Data:

Largely qualitative data have been used in this paper. Data have been collected from secondary sources, such as books, book chapters, journal articles, and publications of governmental organizations and non-governmental agencies. The sources have been quoted under the reference section.

2.4 Methodology of Data Collection:

The author collected qualitative data (required for the study) by review of literature available online. Also, relevant publications available with libraries of universities and institutions of higher education were searched. In addition, this research report benefited from numerous comments and inputs received by policy experts who are in the network of the author.

2.5 Methodology of Data Analysis:

Method of data analysis is descriptive. Collected data (which are 'qualitative' in nature) have been analysed in descriptive manner. Statistical tools and techniques have not been used, as they are more meaningful in situations where "quantitative data base" is used. Desk-based research method has been used by the author in this research.

3. Quick Look at Role of Microbiology in Tackling Food Security:

As indicated in the previous section of this work, an increasing number of countries around the world, in the new millennium, are facing problems associated with food security. Food crisis is proving to be global phenomenon. More and more regions and continents are reported to witness inadequate food productions, partially due to global warming and climate change situations. Several nations in the European Union (EU) are severally hit by drought like situations and other extreme climate weathers (like flooding). All these factors together have resulted in food crisis and associated "food inflation".

Further, in addition to elevated shortage (and competition) for land to grow required crops, ever increasing population and resulting food demand are pushing up prices of key food items, adding burden to the hunger situation.

Furthermore, weather uncertainties (resulting from global warming) and the Covid-pandemic have exacerbated food security and nutrition (FSN) issues. The benefits of significant development made across the regions of the globe over the decades (years) are being reversed. Also, this situation has slowed down the pace of growth and development. Many countries, in today's world situation, are facing growing levels of acute food insecurity, resulting in (a) malnutrition, (b) under-nutrition, and (c) hunger. In view of these situations of food crisis, there is urgent need to resolve this problem. It is for this reason that scientists, today, are looking to microbiology as a possible solution. The author in subsequent sections of this work discusses the most significant ways in which microbiology is being effectively used in order to boost the quality, quantity, and reliability of crop yields [6].

4. Using Microbes to Enhance Crop Yields:

Microbial-based solutions in the agricultural sector are gaining momentum across the developed world in the twenty-first century. Such initiatives are resolving most pressing issues associated with the food industry, namely increasing crop yield. With potential to help significantly enhance FSN situation, across the regions of the globe, significant amount of investment is being made each year into new microbial-based technologies.

At this juncture of this research paper, the author discusses the modality of inter-linkages between application of microbiology and enhanced crop yield. Microbial-based solutions are based on the principle that "microbes influence the growth of plants and the soil in which they grow". Some research and development initiatives have demonstrated that the intervention of "microbe manipulation" can influence microbes to benefit crop yields. It is significant to note that microbes are influenced in the form of:

a) improved growth in crop yield;
b) enhanced resistance to insects;
c) drought prevention;
d) prevention of other extreme weather conditions (like flooding, and unfavorable weather condition) [6].

In the context of discussion on role of microbes in enhancing crop yields and agricultural productivity, it is significant to note that "microbial-based solutions are found to be ensuring environmentally sustainable methods of farming". It is for this reason that "improved crops" and "enhanced soil health" are outcomes, while boosting the resilience of agricultural systems. There are scientific research-based evidences that indicate that some systems associated with microbial-based solutions have the potential to enhance the crop yields by nearly 15%. This data trend shows significant improvements in agricultural productivity; this could translate to millions of tons of extra food produced each year.

In view of these outcomes of microbial-based solutions, microbial systems can be a game-changer, with significant improvements in crop productivity. Over and above, these solutions also ensure "sustainable environment". This is reflected in terms of creating a sustainable future for the food industry, as health of soil is protected from further destruction. This mechanism helps the farmers to ensure that enough (required) food can be produced (now and in the future) for the growing population. Also, it should be noted that "with the intervention of other innovative approaches and developments in science and technology, microbial-based solutions will make significant contributions in ensuring future food security across the continents of the globe [6].

5. Future Use of Microbiology to Improve Food Security and Associated Challenges:

In this section of the present work, the author attempts to look into potential opportunities of application of microbiology in improving FSN situations for the future. Also, the challenges in future use of microbiology in order to improve food security have been touched upon. In this very context, agricultural scientists and policy makers should note that the use of microbial-based solutions, in the present-day situation, is limited. It has still not reached its full potential. This situation (of limited use of microbial system) is evident particularly in developing countries of the globe where both food security and unchecked growth of population are dual pressing issues. The countries need to improve crop yield in order to meet food requirements of both the present and future generations. The use of microbial-based solutions in improving agricultural production in African countries, for example, remains in its infancy, despite the fact that several growth opportunities for the future lies ahead. At this juncture, the author of this work specifically argues that although the developed countries are better-positioned in terms of adopting the emerging technology connected with microbial-based solutions, its full potential has not been achieved; a lot more needs to be done. This measure requires sustained and collaborative efforts between farmers, agricultural scientists and other involved stakeholders. Notably, one hindrance that often comes in way of full utilization of microbial systems is financial constraints. Scientists require experiments and research and this, in turn, need upfront costs of setting up appropriately equipped laboratories to conduct necessary soil microbial research. Soil microbial research is long-term process, involving several rounds of trials and experiments.

More specifically, the author argues that such upfront costs involved with research activities, as outlined above, have acted as a barrier to the adoption of microbial-based solutions in both 'developed' and 'developing' countries. Fortunately, however, it is healthy sign to note that this scenario of financial constraint may change if all stakeholders (in both governmental and non-governmental sectors) join hands together in a more meaningful manner. Also, it will require continuous dialogue and consultation in order to ensure more effective outcomes of microbial-based solutions. In this context, it is very significant to note that the University of Pretoria's Centre for Microbial Ecology and Genomics (in collaboration with nine African countries) recently announced launching of an initiative that is very meaningful. This joint developmental project (initiative) aims to identify the microbial diversity of soil in the African region. Also, the initiative aspires to (a) "uncover the types of microbes that are required for specific crops", and (b) get insight into further knowledge on "how microbial processes influence plant growth". It is expected that with such innovations and collaborative developmental initiatives, the costs involved with setting up microbial-based solutions in the African countries may significantly reduce. This type of joint and collaborative effort, in turn, will make the benefits and outcomes of microbial-based solutions more accessible to all counties [6].

According to considered view of the author of this work, the process of experiments connected with the soil microbial research becomes more challenging (and time-consuming) in view of weather uncertainties brought about by "global warming" and "climate emergency", witnessed globally in the year 2022. In today's world situation, droughts, floods, unusually extremely hot and cold weather situations are being reported (almost on regular basis). This is, in fact, alarming situation which requires urgent attention of national governments and all stakeholders (policy makers) associated with global decision-making bodies, including the UN (United Nations) and its affiliated bodies, including the United Nations Fund for Population Activities (UNFPA).

6. Few Words of Caution for FSN Policy Makers:

The discussion presented above is suggestive of the fact that microbiology can help increase crop yields which, in turn, can enable meeting the goal of "zero hunger". However, the stakeholders associated with the FSN must take note of the large energy and environmental inputs required in applying microbiological processes in agricultural practices. It is pertinent to note that in to achieve desired results in food security, agricultural scientists and researchers need to obtain scientific knowledge needed to promote the activities of microbes (or microbiology) in the soil in manner that ensures "energy efficiency". In view of need for attaining sustainability goals, there is to reduce the use of energy intensive chemicals like fertilizer. Farmers, thus, need to be equipped with skills to utilize microbes in plants in "energy saving ways". They need to engineer microbes to reduce the negative impacts of agricultural inputs [1].

7. Summing Up:

In previous sections, this paper discussed how microbiology will address the global issue of food security. In summary, the author of this work states that microbes influence agriculture and food production processes in a manner that can (a) positively impact crop health, and (b) potentially increase yield. This initiative has helped feed a growing global population, the world over [1]. Microbiology has the potential to provide a sustainable approach for enhancing food security worldwide. This consideration gains increased significance in view of urgency of increasing food production crisis resulting from (a) the impact of the COVID-19 pandemic (on exaggerating inequalities in access to sufficient nutrients), and (b) recently witnessed Russia-Ukraine conflict [6].

With developments taking place in food science and associated areas globally, it is expected that the global agricultural industry, in the coming years, will benefit from microbial-based innovations. The potential outcomes are likely to be more evident, in developing countries, as they are adopting microbes engineering comparatively more effectively. The author, in concluding part of this work, states that new food products and action projects have been launched in the developing world. Significantly, such actions aim to increase the nutrient uptake of key food items. Some of such food items include: (a) 'corn', and (b) 'soy'. Such developments in the field of microbiology (that resulted in "cost-effective food products") help to accelerate the use of microbial-based innovations in the fight against increasing hunger (and food insecurity everywhere, now and for the future generations). However, microbial-based solutions (and innovations) need to be adopted, alongside other currently developing innovations [such as (a) vertical farming methods, and (b) solutions that address food waste] so that food security for future generations is ascertained. [6]. Microbiology can, thus, fight for zero hunger by (a) reducing food spoilage and food-borne outbreaks, (b) increasing food production, and (c) providing innovative and alternative sources of nutrients (over those persistently available).

Declarations and Acknowledgements:

I declare that (a) no funding was received to undertake the study, (b) it is non-plagiarized work, and (c) there is no conflict of interest. The manuscript was originally presented (by in-person mode) at the 5th International Biology Conference 2022 on Research Collaborations and Networking, which was held at International Center for Interdisciplinary Science and Education (ICISE), Quy Nhon, Binh Dinh, Vietnam during August, 17-19, 2022. However, some changes have been made in the present work. I greatly appreciate the assistance provided by numerous academicians who are in my academic and research network: located both in India and abroad. They provided sententious comments in authoring this review research paper.

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DOI:10.31579/2768-0487/105