Next-Generation Sequencing: Bioinputs for Agriculture Innovation

Bioinputs, a sustainable and potent alternative to chemical products used in agriculture, find a position of radical change with the advent of next-generation sequencing (NGS) techniques. These bioinputs, derived from microorganisms, assure the reduction of environmental impact and are able to increase food production. However, proper bioinput development will require the identification of these microorganisms at a level of detail, thereby ensuring a standardized approach. The assessment of potential risks to these microorganisms is thus critical for the safety and efficacy in use, while global collaboration can enable the establishment of standards to be adopted universally.

bioimputs microorganisms next-generation sequencing safety assessment global collaboration

Information
Subjects: Biotechnology & Appl Microbiology
Contributors : Diego Herman Sauka, Leopoldo Palma
View Times: 795
Revisions: 3 times (View History)
Update Date: 03 Apr 2024

1. Introduction

Bioinputs have emerged as pivotal players in global agriculture, aligning with the growing aspiration for a more viable and sustainable farming approach [1]. Offering a less aggressive and environmentally respectful alternative to conventional synthetic chemical products, these inputs, often sourced from microbial origins, hold tremendous potential to significantly reduce the environmental footprint associated with worldwide food production [2], that inexorably needs to supply a population steadily growing.

The nexus between bioinputs production and life expectancy at birth assumes global significance due to its multifaceted impact. These inputs not only enhance the quality of food production by improving crop yields and nutritional content but also contribute to mitigating soil pollution and safeguarding water sources, thereby exerting a positive impact on both global human health and the environment [3]. Microbiology, as a scientific discipline, stands at the forefront of providing sustainable solutions across diverse sectors such as health, food production, the environment, and agriculture [4]. Bioinputs represent a central and distinctive contribution from microbiology, catering to the global quest for the adoption of sustainable agricultural practices.

2. Microorganisms: Powering Bioinputs but Demanding Caution

The utilization of microorganisms as active ingredients in agricultural bioinputs has become a global trend. Bacteria (e.g., *Bacillus subtilis*, *Bacillus thuringiensis*, *Bacillus velezensis*, *Bradyrhizobium japonicum*), fungi (e.g., *Beauveria bassiana*, *Trichoderma bassiana*), and viruses (e.g., Baculoviruses), hailing from different corners of the world, are mass-produced and commercially available to stimulate plant growth, safeguard against pests and diseases, enhancing overall plant performance [5][6][7]. Nevertheless, it is indispensable to recognize that not all microorganisms are universally safe for use in bioinputs production, as their impact can vary across different regions and ecosystems.

3. Mitigating Risks: Safeguarding Human and Environmental Health

Accurately identifying microorganisms before integrating them into bioinputs and thoroughly analyzing available information regarding their safety becomes a global imperative. This is particularly important within the framework of the 'One Health' approach, a comprehensive and interdisciplinary concept extensively discussed in numerous scholarly articles and progressively attracting growing global attention [8].

Maintaining awareness of the risks associated with introducing microorganisms into diverse ecosystems and conducting a thorough assessment of potential negative effects (e.g., potential allergenics, toxins, etc.) before deploying them globally in agriculture is paramount. This approach ensures a globally sustainable and responsible agricultural production model that transcends borders, safeguarding the health of individuals and animals worldwide.

The introduction of microorganisms into new environments can indeed have adverse effects that require careful consideration. For instance, certain microbial strains may produce toxins that could contaminate crops or harm beneficial organisms in the ecosystem [9]. Additionally, unintended consequences, such as the proliferation of invasive species or disruptions to native microbial communities, pose significant risks [10]. Moreover, some microorganisms may induce allergic reactions in humans or animals, posing health hazards to agricultural workers, consumers, and livestock [11]. By thoroughly assessing these potential negative impacts before widespread deployment, stakeholders can effectively mitigate risks and promote the safe and responsible use of bioinputs in agriculture.

4. Advanced Techniques for Precise Identification

To achieve precise identification of microorganisms utilized in global bioinputs production, it is imperative to utilize sophisticated methodologies, including but not limited to massive DNA sequencing (paired with the concomitant and indispensable utilization of bioinformatics), identification via mass spectrometry, and conducting tests in tailored media [12]. These advanced techniques empower accurate identification of microorganisms and their associated risks, even at the species level, thus fostering a standardized global approach.

5. Unveiling the Potential of Next-Generation Sequencing

Massive sequencing, also known as Next-Generation Sequencing (NGS), stands out as a global technique that provides substantial genomic information at once, providing also excellent cost-effective ratios. Taxonomic identification relies on comparing DNA sequences of microorganisms with reference databases, allowing for quicker and more accurate identification than traditional methods [13]. By adopting a uniform approach, we ensure consistency and dependability regardless of the situation. This uniformity promotes coherence in international practices, thereby boosting trust in the results achieved.

In addition to taxonomic identification, NGS can be globally leveraged for the identification of genes associated with virulence factors in pathogenic microorganisms and genes related to antibiotic resistance. This technology also facilitates the discovery of novel strains, such as *Bacillus toyonensis* biovar Thuringiensis, and bioactive compounds, like insecticidal proteins, with interesting biotechnological applications [14]. However, it is crucial to underscore that the mere presence of virulence factors in a microorganism does not automatically imply its potential danger or pathogenicity, as these traits are contingent upon a myriad of contributing factors [15]. Therefore, a comprehensive assessment of the global pathogenic potential of a microorganism should encompass a multifaceted approach, taking into account diverse elements, rather than confining the analysis solely to the identification of virulence-associated genes.

6. The Importance of a Globally Informed Approach

The scientific literature increasingly highlights the potential of numerous microbial strains sourced from diverse regions for use as bioinputs in agriculture. These strains have been associated with both primary pathogenic species such as the bacterium *Bacillus anthracis* [16], and opportunistic ones such as the fungi *Purpureocillium lilacinum* [17], as well as the bacteria *Serratia marcescens* and *Enterobacter cloacae* [18][19]. This underscores the need for a globally informed approach to safety assessments. Collaborative efforts on a global scale in researching microbial diversity and maintaining up-to-date lists of approved species becomes crucial [20]. These initiatives facilitate the global registration and approval process for new products, contributing to the establishment of a harmonized regulatory framework worldwide.

7. Balancing Safety and Innovation: A Shared Responsibility

In their role as global custodians of health and the environment, regulatory authorities worldwide may necessitate comprehensive safety and efficacy studies before allowing the use of new isolates or strains in global bioinputs production. While this may impose constraints on research and development globally, it is crucial to understand that these measures serve as a global control mechanism to ensure the safety and effectiveness of products used in agriculture. Additionally, neglecting genotypic characteristics related to virulence and antibiotic resistance can pose challenges globally in registering bioinputs containing these new microbial strains.

Striking a suitable balance between safety considerations and the indispensable of fostering global innovation in the realm of bioinputs is not merely advantageous but indeed fundamental to the future of sustainable agriculture. Achieving this balance requires concerted efforts on multiple fronts, including global collaboration, the standardization of practices, and a shared commitment to sustainable agricultural practices.

References

1. Maitra, S.; Brestic, M.; Bhadra, P.; Shankar, T.; Praharaj, S.; Palai, J.B.; Shah, M.M.R.; Barek, V.; Ondrisik, P.; Skalický, M.; Hossain, A. Bioinoculants-natural biological resources for sustainable plant production. *Microorganisms*. **2021**, *10*, 51.
2. Santos, L.; Moura, J.; Filho, L.; Teixeira, M.; Peixoto, J. Bioinputs: a sustainable alternative to traditional pesticide cultivation. *Observatorio de la Economía Latinoamericana*. **2023**, *21*, 24777-24816.
3. Upadhyay, H.; Mirza, A.; Singh, J. Impact of Biopesticides in Sustainable Agriculture; Yadav, A.; Rastegari, A.; Yadav, N.; Kour, D., Eds.; Springer: Singapore, 2020; pp. 281-296.
4. Fagunwa, O.E.; Olanbiwoninu, A.A. Accelerating the sustainable development goals through microbiology: some efforts and opportunities. *Access Microbiology*. **2020**, *2*, acmi000112.
5. Dubois, T.; Onsongo, S.K.; Omuse, E.R.; Odhiambo, J.A.; Akutse, K.S.; Mohamed, S.A. Efficacy of Metarhizium anisopliae against the Greater Pumpkin Fly Dacus bivitattus. *Sustainability*. **2023**, *13*, 13185.
6. Nagrale, D.T.; Chaurasia, A.; Kumar, S.; Gawande, S.P.; Hiremani, N.S.; Shankar, R.; Gokte-Narkhedkar, N.; Renu; Prasad, Y.G. PGPR: the treasure of multifarious beneficial microorganisms for nutrient mobilization, pest biocontrol, and plant growth promotion in field crops. *World Journal of Microbiology and Biotechnology*. **2023**, *39*, 100.
7. Liu, W.; Wu, X.; Bai, X.; Zhang, H.; Dong, D.; Zhang, T.; Wu, H. Fusaricidins in Paenibacillus polymyxa A21 and their antagonistic activity against Botrytis cinerea on tomato. *Frontiers of Agricultural Science and Engineering*. **2018**, *5*, 262-270.
8. Mumford, E.L.; Martinez, D.J.; Tyance-Hassell, K.; Cook, A.; Hansen, G.R.; Labonté, R.; Mazet, J.A.K.; Mumford, E.C.; Rizzo, D.M.; Togami, E.; Vreedzaam, A.; Parrish-Sprowl, J. Evolution and expansion of the One Health approach to promote sustainable and resilient health and well-being: A call to action. *Frontiers in Public Health*. **2023**, *10*, 1056459.
9. Brown, R.; Priest, E.; Naglik, J.R.; Richardson, J.P. Fungal Toxins and Host Immune Responses. *Frontiers in Microbiology*. **2021**, *12*, 643639.
10. Pastor, N.; Palacios, S.; Torres, A.M. Microbial consortia containing fungal biocontrol agents, with emphasis on Trichoderma spp.: Current applications for plant protection and effects on soil microbial communities. *European Journal of Plant Pathology*. **2023**, *167*, 593-620.