

Editorial

Microbiome: A Tool for Plant Stress Management in Future Production Systems

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Climate change, due to the altered composition of the global atmosphere from the “greenhouse effect”, is one of the biggest challenges to agricultural production systems. The major effect of climate change is that the average global temperature is increasing continuously, and is predicted to rise by 2 °C by 2100 [1]. This, in combination with other global challenges such as urbanization, diminishing agricultural lands, decreasing biodiversity, and environmental pollution caused by industrialization and the widespread use of agrichemicals, poses a global threat to the food and nutritional security of the entire world. Among the negative effects on agriculture, abiotic (drought, heat cold, salinity, pollutants, heavy metals, nutrient shortage) as well as biotic stresses (pathogens, herbivores) are highly relevant [1]. As an example, a recent study found that drought is currently responsible for approximately EUR 9 billion in annual economic losses across the EU and the UK [1,2]. If countries do not adapt, drought losses could soar to an extraordinary EUR 24 billion with this warming level [1,2]. Prices for synthetic fertilizers continue to rise, and their negative impacts on the environment become more and more apparent and, as a result, nutritional stress escalates to critical levels [3]. This calls for a vast reconsideration of sustainable agricultural practices and future cultivation systems [2,4,5].

Ancient, commonly used long-term agricultural practices, such as the adoption of intercropping and crop rotation focusing on plant communities, are closely associated with the plant-colonizing microbial community and have been beneficially assessed not only for yields and ecosystem services, but also for product quality. Charles Darwin was the first to recognize that domesticated species are different from their wild relatives, and he also recognized the difference between conscious selective breeding, in which humans directly select for desirable traits, and unconscious selection, where traits evolve as a by-product of natural selection. So far, we have confirmed the genetic difference between domestic and wild plants. Wild relatives of crop plants have mechanisms to respond to changing environmental conditions and to settle in extreme habitats. In the same way as humans require the microbiome, several plant species require associations with microorganisms to tolerate stress and to survive [4]. The wild relative’s adaptive capacity under stress conditions is associated with certain microorganisms [6–8]. It is likely that the plants act as organisms composed of numerous genetic lineage interactions with their microbiomes, which are crucial for the development and maintenance under stress situations [4,9]. We must ask the critical question: what are the vital mechanisms that microorganisms use? Can we improve modern crop lines’ tolerance to environmental stresses by understanding the association with certain microorganisms? The answer to these questions will lead us to new and innovative routes towards sustainability.

A few examples from the research: It is suggested that some local varieties of corn grown under traditional agricultural practices with little or no fertilizer could have developed strategies to improve grain yield under conditions of low nitrogen content in the soil,



Citation: Timmusk, S.; de-Bashan, L.E. Microbiome: A Tool for Plant Stress Management in Future Production Systems. *Stresses* **2022**, *2*, 210–212. <https://doi.org/10.3390/stresses2020014>

Received: 28 March 2022

Accepted: 30 March 2022

Published: 6 April 2022

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and in these varieties of corn, 29–82% of the assimilated nitrogen was derived from the atmospheric form N_2 [10]. It has also been suggested that seeds are the place of residence of various microbial communities whose composition is determined by the genotype of the plant, the environment, and management practices [11]. Research shows that selective breeding is a major driver of microbial diversity associated with crop plants, as it focuses on improved crop production and plant root architecture, root exudation and defense responses, by which modified plant microbiota are affected [12]. The domestication of crops has an impact on soil, phenotypes, and physiology [13,14]. For instance, colonization by mycorrhizae is lower, and the infection rate by nematodes is higher in the roots of plants that grow in soils previously cultivated by domesticated plants [13,14].

In general, this indicates that, even though selective breeding has transformed hundreds of wild plant species into productive crop lines, the cultivation practices and intense artificial selection have disrupted interactions between plants and beneficial microbiota. To improve agricultural production and sustainability, research must develop breeding methods to optimize symbiotic results in crop species, and the next generation of plant breeding could adopt an approach that targets the recruitment of symbiotic microorganisms [15]. It is quite clear that the plant microbiome not only helps plants survive in the ecosystem, but also offers critical genetic variability [8,15]. Up to now, little has been applied as a strategy by plant breeders who have traditionally exploited only the genetic variability of the host plant, to develop improved varieties of high yield or with tolerance to diseases, pests, and abiotic stress [15].

To what extent and how selective breeding affects the microbiomes of modern production systems needs further focused study. Therefore, it is highly important that centers of origin and of the species of the associated microorganisms are described [6,16–18]. In order to conserve and restore beneficial traits for stress mitigation, the cultivation systems could be designed based on ecological interactions, focusing on microbiomes present in wild relatives and landraces. Molecular mechanisms of the plant–microbe relationship, underlying gene functions, signal transduction, and genetic basis will provide an extensive and comprehensive knowledge on the phenomenon for further agriculture. It is clear that focusing on microbial–plant interaction can lead to promising solutions for designing environmentally sustainable production systems and the development of products that improve plant health, disease control, and food quality, and increase biotic and abiotic stress management, as well as the restoration of soil health. Microbiome products, which are often referred to as biostimulants/biofertilizers, are defined as any substance or microorganism applied to plants with the direct intention of enhancing nutrition efficiency, abiotic stress tolerance and/or crop quality traits [5]. Biostimulants represent an eco-friendly approach supporting agricultural sustainability, and its sector is growing worldwide, with a market value expected to be USD 2.91 billion by 2021, regarding an area of 24.9 million hectares [5].

As via their microbiomes, plant communities form (generate) sustainable ecosystems, in the same way, we must develop sustainable production systems that also have their root origins in the form of microbial plant interactions, i.e., in this fragile but necessary relationship that gives us great hope for developing a practical and sustainable future.

Funding: This research was funded by Swedish Research Council VR 2921-05471.

Conflicts of Interest: The authors declare no conflict of interest.

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