Торайғыров университетінің
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

ТОРАЙҒЫРОВ УНИВЕРСИТЕТІНІҢ ХАБАРШЫСЫ

Химия-биологиялық сериясы
1997 жылдан бастап шығады

ВЕСТНИК ТОРАЙГЫРОВ УНИВЕРСИТЕТА

Химико-биологическая серия
Издается с 1997 года

ISSN 2710-3544

№ 2 (2024)

Павлодар

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

Химико-биологическая серия
выходит 4 раза в год

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания,
информационного агентства и сетевого издания
№ KZ84VPY00029266

выдано
Министерством информации и коммуникаций Республики Казахстан

Тематическая направленность
публикация материалов в области химии, биологии, экологии,
сельскохозяйственных наук, медицины

Подписной индекс – 76134

https://doi.org/10.48081/YBQU3610

SRSTI 34.27.01

https://doi.org/10.48081/GAUR5915

Hassand Mohammad Hassan[1], Sarwari Atiqullah[2]
[1]Kandahar University, Afghanistan, Kandahar;
[2]Helmand University, Afghanistan, Helmand;
[1,2]Al-Farabi Kazakh National University,
Republic of Kazakhstan, Almaty.
*e-mail: mh.hassand@gmail.com

THE MICROBIAL PLANT ASSOCIATIONS AND THEIR CONNECTION METHODS

As we know, all living things have direct or indirect relationships with each other. Some living things are alive that we cannot normally see with our eyes; that is, they have very small structures, but most of these living things have vital importance in our lives. This paper explores the complex and intimate relationships between certain microorganisms, such as plants, bacteria, and fungi, to include the relationship between mycorrhiza, nitrogen-fixing bacteria, and host mortality. It also highlights the importance of these relationships in nutrient cycling, stress tolerance, and disease resistance. The effects of these relationships on plant fitness and community structure, as well as the complex signaling pathways that control them, are also being studied. However, it emphasizes the importance of understanding such interactions for sustainable agriculture and ecosystem conservation, as well as harnessing these associations to promote resilient and sustainable global ecologies. The microbial plant association is a huge and ever-changing field, ready for scientific exploration. Therefore, this abstract is a call for better understanding to discover hidden features of the life dance, which can help us make our plants healthier and our agriculture practices more sustainable.

Keywords: Microbial communities, plant-microbiome connections, biocontrol, disease resistance and nutrient cycling.

1 Introduction

Plants have a complex network of microbial communities that are crucial for their health and well-being. This partnership is not strictly one-sided, as roots provide shelter and a constant source of sugars and organic molecules, while microbes provide various benefits to their hosts.Interactions among plants and microorganisms are central to our terrestrial ecosystem. There are several types of plant-microbe interactions: competition, commensalism, mutualism, and parasitism [1]. The growth, resistance, and sustainability of plants in communities depend on plant-microbe associations, or microbial plant associations. These relationships are a complicated web of interactions between plants and microbes such as bacteria, fungi, and archaea. There are three types of symbiotic relationships: mutualist, commensal, and parasitic. Using them shapes the fitness of both parties. Nutrients are exchanged in mutualistic relationships like mycorrhizal between plants and fungi, which helps increase nutrient absorption and obtain organic compounds such as carbon. Commensal relationships are advantageous to one party while causing no harm parasitic relationships cause sickness or nutritional imbalances. Such interactions are fundamental to plant biology and have important consequences for crop production, ecosystem functioning, and sustainable development. With activities such as nutrient cycling, disease resistance, and stress tolerance, microorganisms can contribute to the health of a plant. The ability to understand these relationships provides the basis for applications in sustainable agriculture, disease management, and biodiversity maintenance. Research is gradually revealing the complexities of such relations, improving plant performance, and re-establishing environmental balance I hope this article has piqued your interest in the fascinating world of the microbial plant association [2].

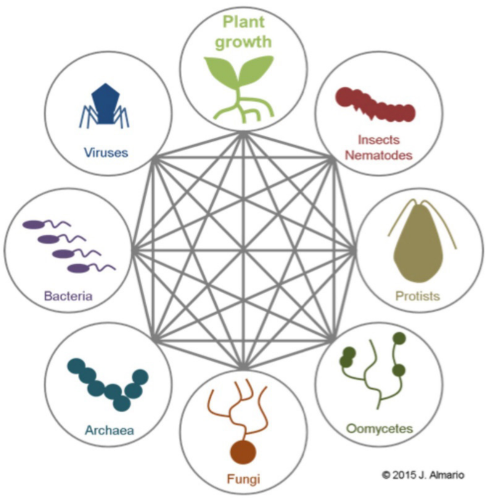

Figure 2 – The importance of microbial networks for plant health

Method and Methodology

It is very essential to study microbial plant associations for agriculture and development. Indeed, such knowledge is helpful in the production of novel and innovative microbial products, including biopesticides and biofertilizers, which enhance agricultural systems' sustainability and resilience. Using the advantages of microbial plant affiliation, farmers and scientists can contribute to more sustainable and stable farming approaches. I collected this research by looking at various scholarly and academic references, including scholarly articles, bibliographies, and other research, and I mostly used the bibliographic method.

2 Plant microbial associations

Plant microbiome relationships are those that involve the interaction between the plants and their symbionts; these play a vital role in their ecophysiology. There are three types of symbiotic relationships: symbiotic, mutualistic, commensal, and parasitic [4]. Mutualistic relationships increase nutrient absorption and organic compounds, while commensal relationships benefit both parties without harm. Parasitic relationships cause sickness or nutritional imbalances. These relationships are essential for crop production, ecosystem functioning, and sustainable development [5]. Microorganisms contribute to plant health through activities like nutrient cycling, disease resistance, and stress tolerance. Understanding these relationships is crucial for sustainable agriculture, disease management, and biodiversity maintenance. Microrhizal and rhizobial symbioses promote growth, nutrient acquisition, and overall ecosystem health [6].

Result and discussion

3 Functions and types of Microbial Plant Associations

Microorganisms (MPA) inhabit the roots of plants, where they perform vital services for their development and prosperity [12]. These microorganisms serve as a dedicated workforce that supplies vital nutrients, protects against pathogens, allows better stress resistance, and improves growth [13]. They play the roles of microscopic «miners» that liberate essential nutrients, defend plants against destructive pathogens, and produce hormones, as well as other bioactive principles to cope with unfavorable stress factors [15]. Improving conditions for beneficial microbes through systematic interventions will lead to fewer chemical fertilizers and pesticides, higher yields and resilience in crops, better soil health, as well as carbon storage potentials, coupled with the development of novel biocontrol strategies against plant diseases [14]. This intricate system of interdependence provides an opportunity to reform agriculture and ecological conservation. Hence, by utilizing the native activities of plant-associated microorganisms, we can decrease reliance on chemical fertilizers and pesticides, enhance crop yields and tolerance capabilities, enhance soil health, and improve natural carbon sequestration while evolving progressive biocontrol technologies for disease control [14]. Now let's get to know the types of microbial plant associations.

3.1. Rhizosphere Microbiome

The rhizosphere is literally the region of ground beneath a plant that interfaces with exudates to pick up sustenance and supplements, including N. P. Khing and Singh (2019). As regards the ecosystem of all living organisms, this is also termed the microbiome, while it involves the rhizosphere.A diverse and heterogeneous community is made up of bacteria, archaea fungi, and protists, etc. The soil microbiome, or rhizosphere, is necessary for plant health and development. It also has the capability to aid in combating diseases, enhance the efficiency of nutrient utilization, and improve the soil feasibility of Titan [7].

3.2. Endophytic Microorganisms

Endophytic microorganisms are non-pathogenic organisms that reside in plant tissues. There are almost all parts of plants that can be found; they include the roots, stem, leaves, and flower. Endophytic microorganisms offer numerous advantages to plants. They may produce hormones that stimulate growth, break down organic material, and prevent pathogenic attacks [8].

3.3. Mycorrhizal Associations

Mycorrhizal association is defined as the symbiotic reunion between plants and fungi. So, the fungus facilitates nutrient absorption by the plant, and in turn, for food supply from the host, it gets carbohydrates. The mutualism of mycorrhizal associations is reciprocal. They promote the growth of plants on nutrient-deficient soils, and they also protect the plants against diseases [9].

3.4. Phyllo sphere Microbiota

The phyllo sphere is part of the aerial section of plants that includes leaves, stems, and flowers. The microbiota of the phyllo sphere indicates the organisms that occupy this surface. It is a less diverse community as compared to that of the rhizome microbiome, but it may have significant effects on plant health [10].

3.5. Nitrogen-Fixing Symbiosis

Nitrogen fixation implies the conversion of atmospheric nitrogen into ammonia that is plant available. Very few bacteria and archaea can perform nitrogen fixation. There are other times when these microorganisms, which fix nitrogen, form symbiotic relationships with the plants. In these symbiotic relationships, the microorganisms supply ammonia to plant parts, from which they get carbohydrates. Plants need nitrogen for their growth and development, but it is limited in soils; hence, the local plant species must find mechanisms for acquiring this element. Nitrogen-fixing symbiosis also plays an important role, especially since plants can acquire another form of nitride [11].

Table 1 – Comparative differences between microbial plant associations

Feature	Types of Microbial Plant Associations					References
	Rhizosphere Microbiome	Endophytic Microorganisms	Mycorrhizal Associations	Phyllosphere Microbiota	Nitrogen-Fixing Symbiosis	
Location	Soil surrounding plant roots	Inside plant tissues	Association between plant roots and fungi	Surface of plant leaves and stems	Root nodules formed by symbiotic bacteria	[7,8,9,10,11]
Microorganisms Involved	Bacteria, fungi, protozoa, viruses	Bacteria, fungi	Fungi (usually from Glomeromycota) and plant roots	Bacteria, fungi, viruses	Nitrogen-fixing bacteria (e.g., Rhizobia)	
Function	Cycle of nutrients and stimulation of plant growth	may improve the availability of nutrients and plant development	promote better plant health and nutrient absorption	affects the resistance to disease and plant health	atmospheric nitrogen's transformation into ammonia	
Mutualistic Relationship	interactions that are mutualistic and synergistic	Mutualistic	The fungus is mutualistic and gains on plant sugars.	Pathogenic or mutualistic interactions are possible.	Mutualistic	
Mode of Interaction	Root exudate secretion and nutrient exchange	Colonization of plant tissues within	Mycorrhizae, or fungal hyphae, infiltrate plant roots.	Microbial encroachment on the surfaces of plants	Plant roots with nodules	
Beneficial Effects on Plants	improved nutritional availability and resilience to illness	improved nutrition absorption and stress capacity	enhanced absorption of nutrients and water, enhanced resistance to pathogens	resistance to disease and growth promotion	Increased availability of nitrogen for plant development	
Examples	The mycorrhizal fungus and rhizobacteria	Mycorrhizal fungus and endophytic bacteria	ectomycorrhizae and arbuscular mycorrhizae	Fungi and epiphytic bacteria	Rhizobium, Azorhizobium, Bradyrhizobium, and so on.	

4 Methods for plant-microbiome connections

4.1. Molecular Techniques

Microbial plant associations are complex interrelationships between plants and microorganisms that promote well-being, productivity, and ecological balance. The relationships between plants and their microbial communities are investigated with the help of molecular techniques such as metagenomics and transcriptomics that show genetic diversity and functional potentialities in these plant-associated microbes. The method of metagenomics provides measurement of genetic diversity and microbial taxa, while transcriptomics analyzes RNA molecules within plant-associated microbes. In this way, these approaches enable the identification of genes upregulated or silenced during plant-microbe relationships and important players such as nutrient homeostasis gene [17, 18].

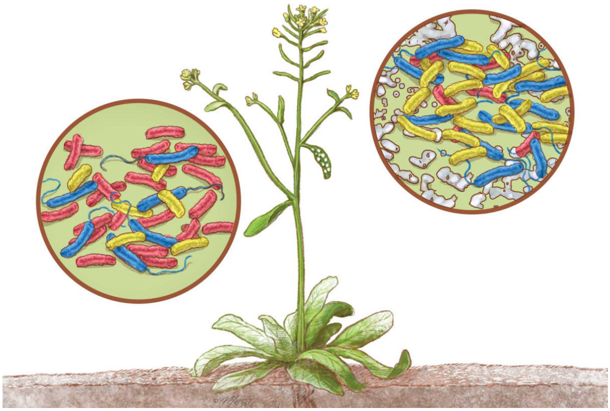

Figure 2 – The plant microbiome

4.2. Chemical signaling method

Microbial-plant symbiotic relationships efficiently expressed by chemical signaling are one of the most incomprehensible yet fascinating types of research, largely essential for understanding interrelationships. The communication system is very different and has a wide variety of molecules that formulate interactions, beginning with mututa to pathogenic. Major signaling proteins, such as phytohormones and microbial-derived metabolites, direct plant responses and colonization behaviors. Studies in these fields shed light on co-evolution and provide opportunities for climate revision in sustainable agriculture, affecting crop productivity and disease resistance. All in all, the study of chemical signaling uncovers mysteries behind labyrinthine biological conversations, which can change what we know about ecology and agricultural practices [16].

4.3. Metagenomics and Meta transcriptomics

Metagenomics and meta-transcriptomics are essential for describing the dynamics of microbial-plant associations. Microbial communities are analyzed through metagenomics, leading to the study of genetic diversity and functional potential in addition to ecological functions. It helps to specify microbial species, establish their genetic content, and describe the possibilities of functioning in the plant-microbe system. Meta-transcriptomics works with the total RNA transcripts produced by a given microbial community, aiming to determine genes involved in processes such as nutrient cycling, plant growth promotion, or defense against pathogens. These approaches provide a real-time snapshot of the molecular interactions that demonstrate the roles played by microbial taxa in plant health and growth [18].

4.4. Microscopic Approaches

Microbial plant partners play a key role in the proper growth, health, and ecological equilibrium of plants. They constitute the symbiosis between plants, and mycorrhizal fungi are, therefore, plant nutrient absorption increasers by providing not just leftovers but keeper carbohydrates. Mycorrhizae branches into two main types: arbuscular mycorrhizae (AM) and ectomyical mycorrhizae, which grow structures referred to as arbusules, which in turn surround plant root tips, resulting in improved uptake of nutrients. Through such symbioses, they not only significantly participate in nutrient cycling within ecosystems but also increase the tolerance of plants to drought and shortages of essential nutrients. These include rhizosphere microorganisms, which are bacteria and fungi acting on important functions to facilitate nutrient cycling, disease control, or plant growth. Most species of bacteria, including some PGPR, work as plant growth-promoting rhizobacteria. PGPR produces hormones that fix nitrogen and solubilize nutrients needed for plant development. For instance, Trichoderma species can act as biocontrol agents against pathogens that do survive in soil and provide plant protection from diseases. Studying microbial community dynamics in the rhizospheric condition enlightens on how these interactions affect plant health, nutrient availability, and ecosystem functioning, which are necessary for sustainable agriculture practices as well as ecological management [18].

4.5. Isolation and Culture-Based Method

Microbial plant interactions are studied using isolation and culture-dependent approaches, which show that these organisms affect growth promotion inhibition or health maintenance. Scientists collect plant material, separate bacteria and fungi, and isolate microorganisms from these pure cultures or mixed communities. Culture-dependent approaches mimic nature, making it possible to evaluate morphological characteristics, analyze the physiological functions of isolated strains, and so on [5].

5 Conclusion

Microbial plant associations are vitally responsible for defining the fate, performance, and output of plants. These associations are a rather complicated web of interrelations between plants and countless microorganisms like bacteria, fungi, and archaea. A crucial piece of information that has been unveiled in this area is the realization of mutualistic relationships between plants and microorganisms, which involve benefits to both parties. For example, mycorrhizal fungi create symbiotic relationships with numerous plants' roots, boosting the plant's ability to absorb nutrients and receive sugars as a result. Secondly, bacteria that are capable of nitrogen fixation, such as Rhizobia, form mutualistic relationships with leguminous plants and provide them with necessary nitrogen compounds in return for carbohydrates. These symbiotic relationships contribute to the general well-being and responsibility of plant communities. A critical component of microbial plant associations is pathogenic interaction. Some microorganisms are phytopathogens that affect plant life, resulting in diminished agricultural output. The mechanisms of pathogenesis have also remained a focal point in research on plant pathology. Infections and diseases can occur if pathogenic microorganisms (specifically, fungi and bacteria) take advantage of weaknesses in plant defense networks. Attempts to unveil the molecular components involved in these processes have shed light on plant immunity and what pathogens do to avoid detection. This information is also essential for formulating policies geared towards minimizing the effects of plant diseases and improving crop protection in agriculture.

References

1 **Wu, C. H., Bernard, S. M., Andersen, G. L., & Chen, W.** (2009). Developing microbe–plant interactions for applications in plant-growth promotion and disease control, production of useful compounds, remediation, and carbon sequestration. Microbial biotechnology, 2(4), 428–440.

2 **Dolatabadian, A.** (2020). Plant–microbe interaction. Biology, 10(1), 15.

3 **Gupta, R., Anand, G., Gaur, R., & Yadav, D.** (2021). Plant–microbiome interactions for sustainable agriculture: a review. Physiology and Molecular Biology of Plants, 27, 165–179.

4 **Johansson, J. F., Paul, L. R., & Finlay, R. D.** (2004). Microbial interactions in the mycorrhizosphere and their significance for sustainable agriculture. FEMS microbiology ecology, 48(1), 1–13.

5 **Ishaq, S. L.** (2017). Plant-microbial interactions in agriculture and the use of farming systems to improve diversity and productivity. AIMS microbiology, 3(2), 335.

6 **Hodge, A., & Fitter, A. H.** (2013). Microbial mediation of plant competition and community structure. Functional Ecology, 27(4), 865–875.

7 **Liu, L., Ma, L., Zhu, M., Liu, B., Liu, X., & Shi, Y.** (2023). Rhizosphere microbial community assembly and association networks strongly differ based on vegetation type at a local environment scale. Frontiers in Microbiology, 14, 1129471.

8 **Nair, D. N., & Padmavathy, S.** (2014). Impact of endophytic microorganisms on plants, environment, and humans. The Scientific World Journal, 2014.

9 **Brundrett, M.** (2004). Diversity and classification of mycorrhizal associations. Biological reviews, 79(3), 473–495.

10 **Gong, T., & Xin, X. F.** (2021). Phyllosphere microbiota: Community dynamics and its interaction with plant hosts. Journal of Integrative Plant Biology, 63(2), 297–304.

11 **Mus, F., Crook, M. B., Garcia, K., Garcia Costas, A., Geddes, B. A., Kouri, E. D., ... & Peters, J. W.** (2016). Symbiotic nitrogen fixation and the challenges to its extension to nonlegumes. Applied and environmental microbiology, 82(13), 3698–3710.

12 **Pii, Y., Mimmo, T., Tomasi, N., Terzano, R., Cesco, S., & Crecchio, C.** (2015). Microbial interactions in the rhizosphere: beneficial influences of plant growth-promoting rhizobacteria on nutrient acquisition process. A review. Biology and fertility of soils, 51, 403–415.

13 **Souza, R. D., Ambrosini, A., & Passaglia, L. M.** (2015). Plant growth-promoting bacteria as inoculants in agricultural soils. Genetics and molecular biology, 38, 401–419.

12 **Munir, N., Hanif, M., Abideen, Z., Sohail, M., El-Keblawy, A., Radicetti, E., ... & Haider, G.** (2022). Mechanisms and strategies of plant microbiome interactions to mitigate abiotic stresses. Agronomy, 12(9), 2069.

15 **Babalola, O. O., Olanrewaju, O. S., Amoo, A. E., Ajilogba, C. F., Chukwuneme, F. C., Ojuederie, O. B., & Omomowo, O. I.** (2023). The functionality of plant-microbe interactions in disease suppression. Journal of King Saud University-Science, 102893.

16 **Venturi, V., & Fuqua, C.** (2013). Chemical signaling between plants and plant-pathogenic bacteria. Annual review of phytopathology, 51, 17–37.

17 **Bukhat, S., Imran, A., Javaid, S., Shahid, M., Majeed, A., & Naqqash, T.** (2020). Communication of plants with microbial world: Exploring the regulatory networks for PGPR mediated defense signaling. Microbiological research, 238, 126486.

18 **Enespa, & Chandra, P.** (2022). Tool and techniques study to plant microbiome current understanding and future needs: an overview. Communicative & Integrative Biology, 15(1), 209–225.

Received 08.02.24.
Received in revised form 15.02.24.
Accepted for publication 27.03.24.

**Мохаммад Хасан Хасанд[1], Сарвари Атикулла[2]*
[1]Кандагар университеті,
Ауғанстан, Кандагар;
[2]Гильменд университеті,
Ауғанстан, Гильменд;
[1,2]Әл-Фараби атындағы
Қазақ ұлттық университеті,
Қазақстан Республикасы, Алматы қ.
08.02.24 ж. баспаға түсті.
15.02.24 ж. түзетулерімен түсті.
27.03.24 ж. басып шығаруға қабылданды.

МИКРОБАЛДЫҚ ӨСІМДІК БІРЛЕСТІКТЕР ЖӘНЕ ОЛАРДЫ ҚОСЫЛУ ӘДІСТЕРІ

Біз білетіндей, барлық тіршілік иелері бір-бірімен тікелей немесе жанама байланыста болады. Кейбір тірі заттар біз әдетте көзбен көре алмайтын тірі; ягни олардың құрылымы өте кішкентай, бірақ бұл тірі заттардың көпшілігі біздің өміріміздe маңызды рөл атқарады. Бұл мақала өсімдіктер, бактериялар және саңырауқұлақтар сияқты кейбір микроорганизмдер арасындағы күрделі және жақын қарым-қатынастарды зерттейді, оган микориза, азотты бекітетін бактериялар және иесінің өлімі арасындағы қарым-қатынас кіреді. Ол сондай-ақ қоректік заттардың айналымы, стресске төзімділік және ауруга төзімділіктегі осы қатынастардың маңыздылыгын көрсетеді. Бұл қатынастардың өсімдік фитнесіне және қауымдастық құрылымына әсері, сондай-ақ оларды басқаратын күрделі сигналдық жолдар да зерттелуде. Дегенмен, ол тұрақты ауыл шаруашылыгы мен экожүйені сақтау үшін мұндай өзара әрекеттесуді түсінудің, сондай-ақ тұрақты және тұрақты жаһандық экологияны ілгерілету үшін осы бірлестіктерді пайдаланудың маңыздылыгын атап көрсетеді. Микробтық өсімдіктер қауымдастыгы – бұл үлкен және үнемі өзгеріп отыратын, гылыми зерттеулерге дайын кен орны. Сондықтан, бұл реферат өсімдіктерімізді сау және ауылшаруашылық тәжірибемізді тұрақты етуге көмектесетін өмір биінің жасырын ерекшеліктерін ашуга жақсырақ түсінуге шақырады.

Кілтті сөздер: Микробтық қауымдастық, өсімдік-микробиома байланысы, биобақылау, ауруга төзімділік және қоректік заттардың айналымы.

**Мохаммад Хасан Хасанд[1], Сарвари Атикулла[2]*
[1]Кандагарский университет,
Афганистан, Кандагар;
[2]Университет Гильменда,
Афганистан, Гильменд;
[1,2]Казахский национальный
университет имени аль-Фараби,
Республика Казахстан, г. Алматы.
Поступило в редакцию 08.02.24.
Поступило с исправлениями 15.02.24.
Принято в печать 27.03.24.

МИКРОБНЫЕ РАСТИТЕЛЬНЫЕ ОБЪЕДИНЕНИЯ И МЕТОДЫ ИХ СВЯЗИ

Как мы знаем, все живое находится в прямых или косвенных отношениях друг с другом. Некоторые живые существа являются живыми, и мы обычно не можем видеть их глазами; то есть они имеют очень маленькие структуры, но большинство этих живых существ имеют жизненно важное значение в нашей жизни. В этой статье исследуются сложные и тесные взаимоотношения между некоторыми микроорганизмами, такими как растения, бактерии и грибы, включая взаимосвязь между микоризой, азотфиксирующими бактериями и смертностью хозяина. Это также подчеркивает важность этих взаимосвязей в круговороте питательных веществ, стрессоустойчивости и устойчивости к болезням. Также изучается влияние этих взаимоотношений на приспособленность растений и структуру сообщества, а также сложные сигнальные пути, которые их контролируют. Тем не менее, в нем подчеркивается важность понимания таких взаимодействий для устойчивого сельского хозяйства и сохранения экосистем, а также использования этих ассоциаций для содействия устойчивой глобальной экологии. Ассоциация микробных растений — это огромная и постоянно меняющаяся область, готовая к научным исследованиям. Таким образом, этот тезис является призывом к лучшему пониманию и обнаружению скрытых особенностей жизненного танца, которые могут помочь нам сделать наши растения более здоровыми, а наши методы ведения сельского хозяйства более устойчивыми.

Ключевые слова: Микробные сообщества, связь растений и микробиомов, биоконтроль, устойчивость к болезням и круговорот питательных веществ.

Теруге 11.12.2024 ж. жіберілді. Басуға 17.12.2024 ж. қол қойылды.
Электронды баспа
4,46 МБ RAM
Шартты баспа табағы 9,50.
Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген А. К. Темиргалинова
Корректорлар: А. Р. Омарова, Д. А. Кожас
Тапсырыс № 4319

Сдано в набор 11.12.2024 г. Подписано в печать 17.12.2024 г.
Электронное издание
4,46 МБ RAM
Усл. п. л. 9,50. Тираж 300 экз. Цена договорная.
Компьютерная верстка А. К. Темиргалинова
Корректоры: А. Р. Омарова, Д. А. Кожас
Заказ № 4319

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
Павлодар мемлекеттік университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
8 (7182) 67-36-69
e-mail: kereku@tou.edu.kz
www.vestnik-cb.tou.edu.kz