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Comparative Soil-Plant Relationship of *Pyrus* L. Species under *in Situ* and *Ex Situ* Conditions

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Abstract. This study conducts a comparative analysis of the soil-plant relationship for *Pyrus* L. species under both *in situ* and *ex situ* conservation environments. It highlights the significance of these conservation strategies, especially given the distinct botanical features of *Pyrus* L. species. The research involved selecting different species within the *Pyrus* genus and systematically gathering sample data. Various methodologies were used to assess both the chemical and physical properties of the soil, employing techniques such as soil texture analysis and nutrient profiling. The findings indicate clear differences in soil-plant interactions across these conservation methods, showcasing how *Pyrus* L. species adapt to their environments and the effectiveness of different protective measures. In particular, the results illustrate the impact of soil composition on plant health and growth in various conservation scenarios. The study concludes by discussing the implications of these findings and suggesting future actions to improve *in situ* and *ex situ* conservation practices. These statements aim to enhance our understanding of *Pyrus* L. species and refine conservation strategies, ultimately supporting the sustainability of these crucial plants.

Keywords: *Pyrus* L. , *In situ*,E*ex situ*, Soil, GIS.

Introduction

The interaction between soil and plants is essential for understanding ecosystem dynamics, particularly for fruit-bearing species like *Pyrus* L. (pear). This genus comprises various species that demonstrate distinct growth behaviors and adaptability to different soil conditions. Studying the comparative soil-plant relationship under *in situ* (natural) and *ex situ* (cultivated) environments provides crucial insights into the ecological needs and agricultural viability of *Pyrus* species.*In situ* settings enable plants to flourish in their native habitats, where optimal soil characteristics and beneficial microbial interactions are present. The author explored how various abiotic factors influence the cultivated dendroflora in Azerbaijan's northeastern region. The research examined the interactions between environmental conditions—such as soil quality, temperature, and moisture—and the growth and health of different tree species (Iskender et al., 2022). These interactions are vital for nutrient cycling and overall plant vitality. In contrast, *ex situ* environments, such as orchards or controlled settings, can significantly modify these relationships, potentially leading to varying growth results.Soil characteristics, such as texture, pH, and organic matter content, influence water retention and nutrient availability. Understanding how these factors affect *Pyrus* species can inform conservation and agricultural practices. The ability of *Pyrus* species to adapt to diverse soil types may reflect their evolutionary background and ecological roles.

Plant growth-promoting bacteria (PGPB) and other beneficial organisms are helping to tackle the challenges of modern agriculture. Recent scientific advancements have created new opportunities for both research and

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commercial applications. In our current study, we compiled recent findings and expert insights on this topic. The overall conclusion is that PGPB are becoming increasingly important in agriculture globally, fostering more sustainable and eco-friendly farming practices while decreasing dependence on artificial fertilizers and chemicals (Kisvarga et al., 2023). The relationship between soil and the microbiome is a crucial and emerging area of scientific research today. The extensive use of Plant Growth-Promoting Bacteria (PGPB) could offer a solution to boost and sustain agricultural production while minimizing environmental harm. Recent advancements in genetic technology are also enhancing the capabilities of microorganisms, potentially accelerating their application in the phytoremediation of metal-contaminated soils (Szilvia, et al ,2023).

The phytoremediation process that relies solely on plants can be slow and may limit metal uptake, particularly in soils with high levels of pollutants. (Hansda et al, 2022). Soil health significantly influences the effectiveness of phytoremediation, as it affects both plant growth and the microbial community. Plant–microbe interactions in the soil are crucial for helping plants adapt to metal-contaminated environments and for enhancing their growth. By exploring these interactions, we can improve microbial-assisted phytoremediation and effectively remediate polluted soils (Ma , 2019).

In this study, the authors conducted an inventory of tree and shrub species found on the Huzurlu High Plateau in Gaziantep, Turkey. The research aimed to document the biodiversity of the region and to analyze the ecological characteristics of the identified species. The findings contribute to a better understanding of the local flora and provide valuable information for conservation efforts and sustainable land management practices in the area (Iskender et al., 2005).

The research findings suggest that the fungal biota affecting fruits and berries in Azerbaijan is not at a critical level, with fungal diseases not exceeding a prevalence of 16.1%. This situation is influenced by soil factors, as soil health plays a crucial role in supporting plant immunity and influencing the prevalence of fungal pathogens. However, given the reality of global issues, this statistic should still be viewed as concerning. Therefore, prioritizing the improvement of soil conditions and implementing preventive measures against these threats is essential for safeguarding crop health (Bakshaliyeva et al., 2020).

Numerous multifunctional and agriculturally significant microbes reside within plant internal tissues (Gupta et.al, 2021). These endophytic bacteria can help alleviate stress in plants, but their effectiveness depends on certain conditions, including the presence and concentration of volatile and bioactive compounds such as ethylene, auxins, phenols, polysaccharides, siderophores, and organic acids (Kahtani et al., 2020).

The study focused on the ecological conditions of Absheron and how they could support the growth and survival of these species. The findings underscore the importance of conservation efforts and provide a framework for future introductions, aiming to enhance biodiversity and restore native ecosystems in the region (Iskenderov, 1993)

In this research work soil quality, encompassing factors like nutrient availability, pH, and organic matter content, can significantly influence pollen viability and fertility. *In situ* conditions usually offer a more complex soil ecosystem that enhances nutrient cycling and microbial interactions, resulting in healthier plants with more viable pollen. In contrast, *ex situ* conditions often consist of cultivated soils with reduced biological diversity, which may not provide optimal growth conditions and could lead to diminished pollen quality and fertility (Jafarzadeh & Iskender, 2024).

Significance of *in Situ* and *Ex Situ* Conservation

There are various species of wild fruit plants that are distributed in the forests of Azerbaijan, including the areas in the northeastern part of the Greater Caucasus. These plant species are a source of raw materials for use in various fields of food and industry. Among these plants, pear species that grow naturally in the study area are of special importance in providing the population of the Republic with healthy ecological food products and in terms of other uses. One of the important aspects of the researched plants is that, in addition to being one of the main components of the forest type in the vegetation, research materials have special roles in the formation of associations or formations.

Wildlife and natural resource conservation involve safeguarding, preserving, managing, and restoring ecosystems, including forests and bodies of water. By prioritizing biodiversity conservation, we can secure the survival of numerous species and habitats facing threats from human activities. There is an urgent need, not only to manage and conserve the biotic wealth, but also restore the degraded ecosystems (Mc Gowen et al., 2016).

In situ conservation involves preserving genetic resources directly within their natural habitats, whether it's safeguarding the genetic diversity of plant species within their native forests or protecting the genetic makeup of animal populations within their natural habitats. It is the process of protecting an endangered plant or animal species in its natural habitat, either by protecting or cleaning up the habitat itself, or by defending the species from predators. It is applied to conservation of agricultural biodiversity in agro forestry by farmers, especially those using unconventional farming practices. *In situ* conservation is being done by declaring area as protected area (Qinglin et al., 2022)

Method

In the 21st century, soil monitoring has gained paramount importance due to climate change, water scarcity issues, and the vulnerability of ecosystems. The necessity to monitor soil environments has become imperative in order to safeguard and preserve them. The soil resource must be recognized as a dynamic living system that emerges through a unique balance and interaction of its biological, chemical, and physical components (Karlen et al., 1997).

Monitoring soil serves not only to manage soil moisture and ensure plant health but also plays a crucial role in understanding various natural processes and water resources, both at the local and regional levels. While many soil sampling methods necessitate composite soil samples obtained by physically mixing soil cores, environmental soil monitoring employs a diverse range of techniques to ensure comprehensive assessment. Utilizing remote sensing for monitoring soil salinity is crucial. Imbalances in soil salinity can adversely affect water quality, crop yields, and infrastructure, underscoring the importance of timely detection and management. Measuring the pH: As many factors such as pollution, climate, and the environment can affect the pH in soil, also helps us understand soil environments.

GIS Applications: *Ex situ* researches were conducted in the Central Botanical Garden of ANAS in 2016. Highly cultivated (N4021'18.1", E4948'51.0"), cultivated (N4021'18.0", E4948'42.0") and poorly cultivated (N4121'26.38", E4848'53.92") 3 soil profile were placed under the soil. Based on the monograph "Modern soil cover of the Greater Caucasus" prepared by the team of the Institute of Soil Science and Agrochemistry of ANAS (M.P. Babayev, Ch.M. Jafarova,A.M. Jafarov, X.M. Gasimov and others) and the 1:100000 scale soil, we determined that *Pyru*s L. species are distributed in situ on northeastern slope of the Greater Caucasus mainly on carbonate mountain-brown, grayish mountain-brown, mountain brown-meadow and mountain gray-brown soils. We placed 4 cuts in Khizi (Altiaghach vil. N40°33'10.60", E48°37'47.04", June 2017) and Guba (Second Nugadi vil. N41°18'47.01", E48°35'47.97" 2017, July) mountain-brown grass, in Siyazan (Dağ Gushchu vil. N40°59'46.09",E48°57'38.20", 2017, July) and in Shabran (Pirabadil vil. N41°12'5.65",E48°48'2.54", 2017, August) under mountain-gray-brown soils.

Granulometric calculation of soil from soil taken from the study area. – N.A. Kachinsky (Kachinsky,1958), humus – I.V. Tyurin (Mineeva, 1989), total nitrogen Kyeldal (Mineeva, 1989), total phosphorus - Lawrence; total potassium – Smith's method; environmental response - with pH meter, dry residue by Ivanov's method (according to specific gravity); absorbed bases (Ca+Mg) – D.V. Ivanov method, CO_2-Scheibler method; (Mineeva, 1989), carbonation was determined according to CO_2 (Arınushkına, 1970).

The method of using a hydrometer was chosen to determine the soil texture, while the pH of the soil was analyzed in a soil-water suspension with a ratio of 1:2.5. The method of using a hydrometer was chosen to determine the soil texture, while the pH of the soil was analyzed in a soil-water suspension with a ratio of 1:2.5.Cation exchange capacity (CEC) was determined by saturating the samples with sodium acetate; exchangeable cations (Na, K, Ca and Mg) with ammonium acetate; electrical conductivity (EC) in 1.0:2.5 soil-water saturation and organic matter using Walkley-Black method (Arinushkina, 1970; Durak, Saltali, Oghuz & Kilich,2007).

Soil is a dynamic natural body developed as a result of pedogenic processes through weathering of rocks, consisting of mineral and organic constituents, possessing definite chemical, physical, mineralogical and biological properties, having a variable depth over the surface of the earth, and providing a medium for plant growth Soil supports terrestrial life through five processes: (1) biomass productivity, (2) restoration and resilience of ecosystems, (3) purification of water, (4) detoxification of pollutants, and (5) cycling of C, N, P, S, and H_2O (Karlen et al., 1997).

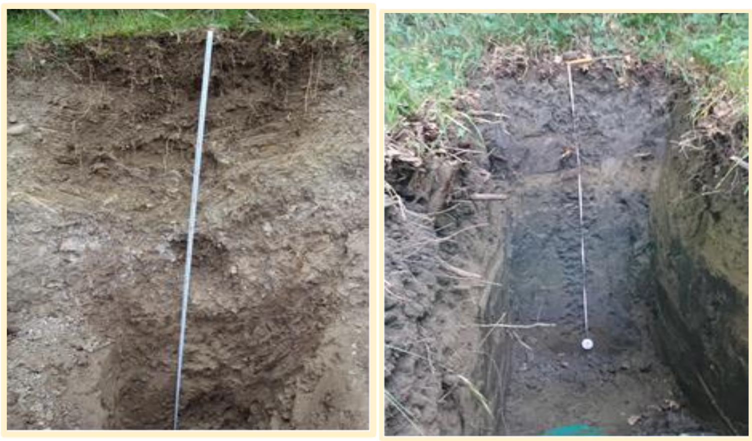
Results and Discussion

The soil-forming rocks of the Central Botanical Garden are composed of sea and lake sediments, fish-ear limestones, gypsum-saline and sandy Absheron clays and their weathering products. M.P. Babayev and etc. based on their research, it was determined that raw and irrigated cultivated types of gray-brown soils are distributed in the area. As we mentioned, based on the laboratory analysis, it was determined that the amount of humus in irrigated gray-brown soils is higher than in raw soils, so the amount of humus in the planting layer (AUa 25-45 cm) of highly cultivated soils is 1.48-2.67%, cultivated gray-brown it varies between 1.38-1.85% in soils, and between 0.44-0.75% in the poorly cultured version. Regarding the amount of total N, nitrogen in the soil of the Central Botanical Garden ranges from 0.07-0.20%, and the ratio of C:N varies between 5.6-7.2. In the irrigated gray-brown soils of the area, the amount of carbonates is high in the upper layer (16-18%), and decreases along the profile (9-14%) (Table 1.).

Table 1. Fertility indicators of central botanical garden soils

Soil profile number	Depth of genetic layers (cm)	Humus, %	Total nitrogen %	Total P_2O_5%	Total K_2O, %	pH (water)	Absorbed sum of bases, mq/ekv	Dry residue,%	Granulometric composition		CO_2, %	$CaCO_3$, %
									<0,01 mm	<0,001 mm		
					Highly cultivated irrigated gray-brown soil							
1	AU'a 0-25	2,67	0,20	0,18	1,9	7,8	23,0	0,139	32,0	9,0	2,2	18,2
	AU"a 25-45	1,48	0, 12	0,16	1,6	7,9	22,0	0.200	29,9	10,1	2,3	15,9
	Bca 45-82	0,52	0,05	0,12	1,4	8,1	19,8	0, 122	33, 6	13,8	2,4	17,3
	Cl 82-120	0,20	-	0,09	1,0	8,2	17,7	0, 130	22,0	8, 5	2,1	11,0
	Cll 120-153	0,18	-	-	-	8,4	18,4	0, 141	29,8	5,7	2,1	-
					Cultivated irrigated gray-brown soil							
2	AU'a 0-24	1,85	0,15	0,15	1,7	7,9	23,2	0.082	44.0	19,9	2,0	19,8
	AU"a 24-56	1,38	0,12	0,12	1,3	7,8	18.7	0,112	48.9	15.2	1,9	20,7
	Bca 56-82	0,66	0,05	0,12	1,2	8,0	17,6	0,110	42.3	18,0	2,1	19,0
	Cs 82-113	0,45	-	0,11	0,8	8.1	16,5	0,114	38,0	14.2	2,2	14,7
	Cs 113-150	0,19	-	-	-	8,2	17,1	-	49.3	18.8	-	10,2
					Poorly cultivated gray-brown soil							
3	Ala 0-18	0,75	0,07	0,12	1,3	8, 0	15,0	0,090	13,8	5,7	2,1	16,0
	B/C 18-34	0,44	0,06	0,11	1,2	8,1	15,7	0,071	15,9	6,9	2,2	15,7
	Cl 34-85	0,38	003	0,10	1,0	8,3	15,8	0.078	18.0	5. 0	2,3	19,0
	Cll 85- 120	0,23	-	0,09	0,5	8,4	14,0	0,093	21,4	6.4	2,2	21,9
	Cs 120- 165	0,18	-	-	-	8,5	13,2	0,082	30.5	6.2	2,0	22,3

According to the degree of provision of absorbed bases, the highly and medium cultivated gray-brown soils of the Central Botanical Garden are moderately (23.1-23.2 mg-eq), and the poorly cultivated variant is provided to a low extent (15.0-15.7 mg-eq). The amount of Ca^{2+} cation is 46-62% of the total absorbed bases, and the amount of Mg^{2+} is high, 17-39%. The fact that the amount of Na+ cation in the profile of these soils is 6.5-8.0% indicates that the soils are acidic. Based on the monograph "Modern soil cover of the Greater Caucasus" prepared by the team of the Institute of Soil Science and Agrochemistry of ANAS (M.P. Babayev, Ch.M. Jafarova, A.M. Jafarov, Kh.M. Gasimov and others), we determined that *Pyrus* L. species are distributed in situ on the northeastern slope of the Great Caucasus mainly on carbonate mountain-brown, grayish mountain-brown, mountain brown-meadow is (6.7-8.3) and mountain gray-brown soils (Babayev et al., 2017).



Altıaghach, Khizi district

Guba district ***Siyazan district***

Shabran

Figure 1. Soil cross section under species of the genus *Pyrus* L. in the northeastern part of the Greater Caucasus.

Figure 1. that illustrates a soil cross-section beneath plants belonging to the genus *Pyrus* L. The setting is specified as the northeastern region of the Greater Caucasus. Mountain brown-meadow soils are spread in the foothills of the Greater Caucasus, in the Guba-Khachmaz sloping plain, and are similar to brown soils in many of their characteristics. However, unlike brown soils, these soils do not obey the zonal law and do not form any belt (Babayev et al., 2017). These soils were mainly formed in hydromorphic conditions, as groundwater is distributed in areas closer to the surface. In the profile of these soils, there is a turf layer in the upper layer, it has a heavier mechanical composition, the carbonate illuvial layer is thinner, and the amount of carbonates is low. Since the forests were cut down in the areas where mountain brown-meadow soils spread for a long time, grass and shrub plants developed in those places. Depending on the amount of precipitation falling on the northeastern slope of the Great Caucasus and the lithological composition of the rocks, the level of groundwater also varies (Babayev et al., 2017) .The soil-forming rocks of the areas where mountain brown-meadow soils are spread are composed of ancient alluvial sediments of clayey, gravelly and carbonate origin.

In mountain brown-meadow soils, the amount of humus is 2.3-3.2% in the upper layer, and a sharp decrease is observed towards the depth - 0.6%. The amount of total N is 0.16-0.21% in the upper layer and decreases to 0.10% towards the lower layers (Table 2.). The amount of carbonates in these soils is the same throughout the profile, only in the deep layers there is an increase - 7.0-22.4%.

The absorption capacity of mountain brown-meadow soils varies between 18-24 mg-eg on average, and a decrease is observed along the profile. Although Ca cation dominates in the upper layer of the profile of these soils, it is observed that the amount of $Mg2+$ increases in the lower layers - 7.5-10.47 mg-eg, which, in turn, indicates that $Mg2+$ is spreading in these soils (Babayev et al., 2017) . In mountain brown-meadow soils, the reaction of the environment is pH 7.9-8.2 in the upper layers, increasing alkalinity towards the lower layers (Table 2.). According to the mechanical composition of these soils, the clay content increases with depth.

Table 2. Fertility indicators of the soils of the northeastern slope of the greater caucasus

Soil profile number	Depth of genetic layer	Humus, %	Total nitrogen, %	Total P_2O_5, %	Total K_2O, %	Carbonate, %		pH (water)	Absorbed sum of bases, mq/ekv	Granulometric composition, %	
						CO_2	$CaCO_3$			<0,01	<0,001
Mountain brown-meadow soils											
Altiaghach 4	0-25	2,2	0,16	0,17	2,0	4,2	10.2	7,9	18,00	46,75	17,88
	25-35	2,1	0,12	0,15	2,1	5,0	11.4	8,0	17,30	66,17	19,75
	35-55	1,6	0,11	0,13	1,9	5,2	13.7	8,1	16,42	58,46	26,42
	55-87	1,2	0,10	0,08	2,2	7,8	17.2	8,2	15,36	55,00	20,56
	87-120	0,6	-	0,06	2,3	6,3	22.4	8,3	13,48	37,52	17,76
Guba 5	0-10	3,2	0,21	0,16	2,4	3,3	7.0	8,2	24,30	48,32	18,45
	10-25	2,3	0,17	0,14	2,3	2,4	5,3	8,3	19,12	65,12	26,76
	25-60	2,1	0,14	0,12	2,2	2,8	5,6	8,1	19,35	60,72	12,24
	60-95	1,5	-		2,0	3,3	8.0	8,1	18,16	28,30	10,20
	95-145	1,0	-	0,06	-	4,4	9,9	8,3	17,52	25,45	9,24
Mountain gray-brown soils											
Siyazan 6	0-20	2,2	0,17	0,18	2,3	6,0	13,5	7,5	23,45	70,18	31,70
	20-45	1,6	0,15	0,16	2,2	7,1	14,8	7,7	19,72	69,20	25,00
	45-67	1,3	0,13	0,13	2,1	5,9	14,6	8,1	15,36	66,35	41,36
	67-90	1,0	0,09	0,10	2,0	4,3	10, 5	8,3	14,73	69,42	34,82
	90-115	0,5	0,04	0,09	2,0	8,9	22,7	8,2	12,76	60,32	24,70
	115-150	0,2	-	0,08	1,9	8,3	19,3	8,3	11,46	70,26	21,60
Shabran 7	0-7	3,1	0,20	0,09	2,3	5,0	11,6	8,3	17,10	55,32	26,58
	7-25	1,2	0,12	0,07	2,2	5,5	12,4	8,4	15,46	48,00	23,35
	25-60	0,7	0,08	0,05	2,0	6,9	15,2	8,3	18,30	32,35	19,46
	60-100	0,5	0,07	0,01	1,8	9,2	23,8	8,2	17,21	28,52	15,00

On the northeastern slope of the Greater Caucasus, mountain gray-brown soils are spread in the middle of the Gusar foothill plain in the form of a thin strip .Although the amount of humus is 2.2-3.1% in the upper layer, a strong decrease is observed below 30 cm - 1.2% (Table 2). The amount of total nitrogen in the top layer is 0.17-0.20%. It is noteworthy that these soils are highly carbonated and the illuvial-carbonate layer is located in the deep layers of the soil profile: 13.5-22.7%. On the steep slopes in the surrounding areas of Shabran and Siyazan, primitive mountain gray-brown soils are spread, the humus layer is thin in these soils, and skeletal structure is observed below 50-70 cm.

Due to the amount of readily soluble salts, the mountain gray-brown soils are weakly saline - 0.15-0.22%. The mechanical composition of mountain gray-brown soils is clayey and heavy loamy. The amount of silt particles is 26-31%, the amount of particles <0.01 mm in size is 55-70% in the upper layer of the profile, it decreases towards the lower layers and is 28-60% (Table 2).

Conclusion

In summary, the comparative analysis of soil-plant relationships in *Pyrus* L. species under *in situ* and *ex situ* conditions offers valuable insights into their ecological and agricultural relevance. Our results indicate that soil characteristics play a crucial role in influencing the growth, health, and productivity of *Pyrus* species. Typically, *in situ* conditions provide a more integrated environment that fosters natural microbial interactions, leading to better nutrient absorption and disease resistance. While *ex situ* environments can facilitate controlled cultivation, they may introduce factors that affect plant performance differently than in natural settings. Recognizing these differences enables us to optimize agricultural practices to more closely resemble natural conditions, thus promoting healthier plants and higher yields. The ability of *Pyrus* species to adapt to various soil types highlights their potential for cultivation across diverse agricultural landscapes. This research underscores the significance of adopting suitable soil management practices that cater to the specific needs of *Pyrus* species. Employing sustainable soil practices can yield long-term advantages for both agricultural productivity and ecosystem health. By focusing on soil quality and health, we can enhance the resilience of *Pyrus* species against environmental challenges, such as climate change and soil deterioration. In essence, the complex relationship between *Pyrus* species and their soil environments is crucial for both ecological stability and agricultural sustainability. Future research should continue to delve into these relationships, exploring the effects of various soil amendments and management strategies. Such investigations will be essential for enhancing our comprehension of plant-soil interactions and improving ecosystem health. Ultimately, cultivating a deeper understanding of these relationships can lead to more responsible and effective agricultural and conservation practices. As we advance, it is vital to integrate scientific insights into practical applications that serve both human interests and the environment. Examining the physiological responses of *Pyrus* species to different soil environments can provide insights into their resilience against environmental stressors, such as drought and salinity. This is especially relevant in the context of climate change, which presents significant challenges to both agriculture and natural ecosystems.

In conclusion, examining the comparative soil-plant relationship of *Pyrus* species in both *in situ* and *ex situ* conditions is a vital area of study. It not only deepens our understanding of plant ecology but also offers practical insights for agricultural practices and conservation efforts. Through this investigation, we aim to contribute to the broader field of plant-soil interactions, highlighting the importance of maintaining healthy ecosystems for future generations.

Recommendations

1. Habitat Conservation: Prioritizing the protection of natural habitats where *Pyrus* species flourish to maintain their genetic diversity and ecological functions.
2. Controlled Experiments: Conducting *ex situ* experiments that closely mimic natural conditions to gather data on how *Pyrus* species respond to various soil types and management practices.
3. Nutrient Management Plans: Creation tailored nutrient management plans for *Pyrus* species, focusing on balanced fertilization to minimize reliance on synthetic fertilizers.
4. Environmental Monitoring: Establishment programs to monitor environmental stressors like drought, salinity, and pests, aiding in the development of strategies to mitigate their effects on *Pyrus* species.

Scientific Ethics Declaration

As researchers engaged in the study of *Pyrus* L. species and their interactions with soil environments, we commit to upholding the highest standards of scientific integrity and ethical conduct throughout my work.

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