forests

Editorial

Strategies for Tree Improvement under Stress Conditions

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1. Introduction

Forests are vital ecosystems, covering a significant portion of the Earth's land area and providing essential ecological services and valuable products for human society [1]. However, forests face numerous challenges, including climate change, water deficits, nutrient limitations, and the emergence of pests and diseases [2]. To ensure the resilience and sustainability of forests, it is crucial to understand the genetic and molecular mechanisms underlying tree responses to these stressors. This Special Issue on "Strategies for tree improvement under stress conditions" presents a collection of 19 research papers that contribute to the recent advances of physiological and molecular mechanisms in woody plants in adapting to stress conditions.

2. Drought

Research papers in this collection explore various aspects of tree genetics and molecular responses to drought stresses. In one study, the effects of water deficit on artificially bred poplar hybrids were investigated, revealing that male siblings exhibit better protection than female siblings under water-deficient conditions [3]. Li et al. investigated the impact of nitrogen (N) supply on water uptake, drought resistance, and hormone regulation in *Populus simonii* seedlings under PEG-induced drought stress and reveal that increasing N supply may enhance drought tolerance by reducing transpiration rate and oxidative stress while improving water uptake and antioxidant activity [4]. The overexpression of the *SpsNAC005* gene promotes growth, development, and stress tolerance in transgenic plants under drought conditions [5]. The expression levels of *MaTCP2*, *MaTCP4-1*, *MaTCP8*, *MaTCP9-1*, and *MaTCP20-2* exhibited a significant correlation with the process of root development, suggesting their involvement in regulating root growth under drought conditions [6]. Furthermore, these identified MaTCP transcription factors hold potential implications for enhancing the drought tolerance of mulberry plants [6]. Liu et al. identified and analyzed 18 auxin response factors (ARFs) in *Santalum album* and tissue-specific expression and drought-induced expression patterns were observed, with six genes overexpressed in haustorium and three genes overexpressed under drought stress [7]. These findings provide insights into the functions of *S. album* ARF genes, particularly in haustorium formation and response to drought stress [7]. *Robinia pseudoacacia* can access shallow soil water in wet years and utilize deeper soil water in dry years to maintain growth and resistance to drought stress, which provide the solutions for rainwater resource planning and management in forest plantations [8].

Citation: Luo, J.; Hu, W. Strategies for Tree Improvement under Stress Conditions. *Forests* **2023**, *14*, 1320. https://doi.org/10.3390/f14071320

Received: 16 June 2023
Accepted: 26 June 2023
Published: 27 June 2023

3. Heavy Mental

Heavy mental accumulation in soils affects the normal growth of plants; however, the exogenous application of nutrients may mitigate the toxic effects of heavy metals. Here, Li et al. suggest that high-dose Fe mitigates Cd-induced growth suppression, promotes Cd transport to aboveground tissues, and enhances antioxidant capacity in poplar, which provides insights for Cd-contaminated soil remediation using poplar [9]. Wang et al. investigated the effects of selenium (Se) on cadmium (Cd) accumulation and the physiological mechanisms underlying Se-mediated regulation of Cd-induced oxidative stress in *Juglans regia*, suggesting that the exogenous application of Se, especially at 200 μM, reduces Cd accumulation, enhances antioxidant enzyme activities, and alleviates Cd-induced stress in walnut roots [10]. Another study focused on the transcriptomic response to zinc stress in mulberry, uncovering organ-specific differences in gene expression [11].

4. Salinity

Saline is one of the most serious abiotic stresses that affecting plant growth and development worldwide [12]. Zhang et al. found that grafting can ameliorate the inhibition of salinity on the photosynthetic capacity of *Hibiscus syriacus*, mainly resulting from alleviated limitations on photosynthetic pigments, photochemical efficiency, and the Calvin-Benson–Bassham cycle [13]. Additionally, the overexpression of the poplar *WRKY51* transcription factor was found to enhance salt tolerance in *Arabidopsis thaliana*, demonstrating the potential of genetic engineering for improving tree resilience [14]. Pang et al. showed that highly expressed transcription factor genes were correlated with key salt tolerance indices, suggesting their potential as genetic resources for salt tolerance breeding in *Salix matsudana* [15]. Moreover, the overexpression of *SpsNAC005* from *Salix psammophila* in poplar significantly improved its tolerance to salt stress [5].

5. Nutrient

N is one of the most important macronutrients for growth and development in woody plants, and applications of N can significantly increase productivity [16,17]. Responses of fine root traits and soil nitrogen to fertilization methods and N application amounts in a poplar plantation were investigated, shedding light on the interactions between tree roots and soil nutrient availability [18]. NH_4^+-N and NO_3^--N distributions have different impacts on the root morphology and growth of *Cunninghamia lanceolata* and *Schima superba* seedlings, in which tailoring N application based on N form and plant species is recommended for seedling cultivation [19]. The influence of trace elements on the traits and active compounds of *Camellia oleifera* in nutrient-poor forests was also examined, revealing that exogenous applications of zinc and Se could significantly improve the qualities of its fruits [20]. The trace element boron has been shown to be essential for woody plants overcoming stress conditions [21]. Liu et al. uncovered the effects of *Funneliformis mosseae* inoculation on *C. oleifera* seedlings under normal and boron deficient conditions and found that AMF inoculation improves boron deficiency resistance and that AMF colonization is influenced by boron availability [22].

6. Other Strategies for Tree Improvement

The genome-wide identification of the *PP2C* gene family and expression-level analyses of the PP2Cs in *Paulownia fortunei* in response to rifampicin and methyl methanesulfonate treatments were studied, providing insights into their potential roles in stress responses [23]. The chemical composition of walnut oil, including fatty acids, micronutrients, and secondary metabolites, was analyzed in different walnut species and hybrids cultivated at various sites [24]. Significant variations in composition and content were observed between species and sites, which could be valuable for site selection and improving the nutritional quality of walnut oil [24]. Differentially methylated regions (DMRs) and associated genes (DMGs) after gtafting in pecan were analyzed, which identified the key genes involved in hormone response, suggesting their crucial roles in graft growth regulation [25]. This study provides valuable insights into the epigenetic mechanisms underlying rootstock-induced growth changes in pecan, paving the way for tree improvement using grafting in this plant species [25].

7. Conclusions and Prospects

These research papers collectively highlight the significance of molecular genetics and genomics in addressing the challenges faced by forest ecosystems. By unraveling the genetic basis of tree responses to various stressors, we can develop targeted strategies for tree improvement, conservation, and sustainable forest management. Furthermore, these studies encompass a wide range of tree species, including economically important species, rare and endangered species, and ecologically significant trees, broadening our understanding of forest species beyond model species.

As guest editors, we believe that this Special Issue presents a valuable compilation of research findings that contribute to tree improvements under stress conditions. The diversity of species, conditions and genetic traits investigated underscores the potential of molecular genetics to enhance forest health, ecosystem services, and sustainable production. However, more research is needed to further expand our knowledge and address the complex challenges faced by forests in the face of climate change and other stressors. By continuing to explore the intricacies of tree physiology and genetics, we can pave the way for a more resilient and sustainable future for our forests and the multitude of benefits they provide.

Funding: The study was supported by the Fundamental Research Funds for the Central Universities (Grant no. 2262022YLYJ007).

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

References

1. Gamfeldt, L.; Snäll, T.; Bagchi, R.; Jonsson, M.; Gustafsson, L.; Kjellander, P.; Ruiz-Jaen, M.C.; Fröberg, M.; Stendahl, J.; Philipson, C.D.; et al. Higher levels of multiple ecosystem services are found in forests with more tree species. *Nat. Commun.* **2013**, *4*, 1340. [CrossRef] [PubMed]
2. Arora, N.K.; Fatima, T.; Mishra, I.; Verma, M.; Mishra, J.; Mishra, V. Environmental sustainability: Challenges and viable solutions. *Environ. Sustain.* **2018**, *1*, 309–340. [CrossRef]
3. Chen, F.; Gong, Y.; Liu, S.; Wang, Y.; Luo, L.; Zhu, G.; Zhao, H. More effective protection supports male better than female siblings over water deficit in artificially bred poplar hybrids. *Forests* **2023**, *14*, 995. [CrossRef]
4. Li, Z.; Wang, X.; Liu, Y.; Zhou, Y.; Qian, Z.; Yu, Z.; Wu, N.; Bian, Z. Water uptake and hormone modulation responses to nitrogen supply in *Populus simonii* under PEG-induced drought stress. *Forests* **2022**, *13*, 907. [CrossRef]
5. Yang, H.; Fan, L.; Yu, X.; Zhang, X.; Hao, P.; Wei, D.; Zhang, G. Analysis of the NAC gene family in *Salix* and the identification of *SpsNAC005* gene contributing to salt and drought tolerance. *Forests* **2022**, *13*, 971. [CrossRef]
6. Wei, W.; He, J.; Luo, Y.; Yang, Z.; Xia, X.; Han, Y.; He, N. Root-growth-related matcp transcription factors responsive to drought stress in mulberry. *Forests* **2023**, *14*, 143. [CrossRef]
7. Liu, X.; Liu, Y.; Wang, S.; Qin, F.; Wang, D.; Chen, Y.; Hu, L.; Meng, S.; Lu, J. Complete genome expression analysis of the Auxin Response Factor gene family in sandalwood and their potential roles in drought stress. *Forests* **2022**, *13*, 1934. [CrossRef]
8. Ma, C.; Meng, H.; Xie, B.; Li, Q.; Li, X.; Zhou, B.; Wang, Q.; Luo, Y. In situ rainwater collection and infiltration system alleviates the negative effects of drought on plant-available water, fine root distribution and plant hydraulic conductivity. *Forests* **2022**, *13*, 2082. [CrossRef]
9. Li, M.; Liu, C.; Zhang, D.; Wang, B.; Ding, S. The influence of iron application on the growth and cadmium stress tolerance of poplar. *Forests* **2022**, *13*, 2023. [CrossRef]
10. Wang, B.; Zhang, D.; Wang, W.; Song, Y.; Lu, M.; Ding, S. Foliar application of selenium reduces cadmium accumulation in walnut seedlings. *Forests* **2022**, *13*, 1493. [CrossRef]
11. Huang, S.; Kang, X.; Yu, T.; Yidilisi, K.; Zhang, L.; Cao, X.; Chao, N.; Liu, L. Comparative RNA-Seq analysis reveals the organ-specific transcriptomic response to zinc stress in mulberry. *Forests* **2023**, *14*, 842. [CrossRef]
12. Luo, J.; Shi, W.; Li, H.; Janz, D.; Luo, Z.-B. The conserved salt-responsive genes in the roots of *Populus* × *canescens* and *Arabidopsis thaliana*. *Environ. Exp. Bot.* **2016**, *129*, 48–56. [CrossRef]
13. Zhang, S.; Yu, W.; Lu, Z.; Xiang, P.; Wang, Z.; Hua, J.; Gu, C.; Cai, J.; Lu, Y. *Hibiscus hamabo* rootstock-grafting improves photosynthetic capacity of *Hibiscus syriacus* under salt stress. *Forests* **2023**, *14*, 1226. [CrossRef]
14. Zhou, Y.; Li, Q.; Zhang, Y. Overexpression of the poplar *WRKY51* transcription factor enhances salt tolerance in *Arabidopsis thaliana*. *Forests* **2023**, *14*, 191. [CrossRef]

15. Pang, Y.; Guo, L.; Wang, T.; Liu, W.; Mao, P.; Cao, X.; Geng, Y.; Cao, B. Screening of key indices and the gene transcriptional regulation analysis related to salt tolerance in *Salix matsudana* seedlings. *Forests* **2022**, *13*, 754. [CrossRef]
16. Li, Z.; Deng, S.; Zhu, D.; Wu, J.; Zhou, J.; Shi, W.; Fayyaz, P.; Luo, Z.-B.; Luo, J. Proteomic reconfigurations underlying physiological alterations in poplar roots in acclimation to changing nitrogen availability. *Environ. Exp. Bot.* **2023**, *211*, 105367. [CrossRef]
17. Luo, J.; Zhou, J.-J. Growth performance, photosynthesis, and root characteristics are associated with nitrogen use efficiency in six poplar species. *Environ. Exp. Bot.* **2019**, *164*, 40–51. [CrossRef]
18. Yan, X.; Dai, T.; Gao, Y.; Di, N.; Jia, L. Responses of fine root traits and soil nitrogen to fertilization methods and nitrogen application amounts in a poplar plantation. *Forests* **2023**, *14*, 282. [CrossRef]
19. Liang, H.; Wang, L.; Wang, Y.; Quan, X.; Li, X.; Xiao, Y.; Yan, X. Root development in *Cunninghamia lanceolata* and *Schima superba* seedlings expresses contrasting preferences to nitrogen forms. *Forests* **2022**, *13*, 2085. [CrossRef]
20. Dai, Q.; Deng, Z.; Pan, L.; Nie, L.; Yang, Y.; Huang, Y.; Huang, J. Effects of trace elements on traits and functional active compounds of *Camellia oleifera* in nutrient-poor forests. *Forests* **2023**, *14*, 830. [CrossRef]
21. Luo, J.; Liang, Z.; Wu, M.; Mei, L. Genome-wide identification of *BOR* genes in poplar and their roles in response to various environmental stimuli. *Environ. Exp. Bot.* **2019**, *164*, 101–113.
22. Liu, J.; Zhang, M.; Fan, J.; Ding, W.; Chen, L.; Luo, J.; Liu, Y.; Mei, L. The synergistic effects of AMF inoculation and boron deficiency on the growth and physiology of *Camellia oleifera* seedlings. *Forests* **2023**, *14*, 1126. [CrossRef]
23. Zhao, Z.; Zhang, P.; Deng, M.; Cao, Y.; Fan, G. Genome-wide identification and expression analyses of the *PP2C* gene family in *Paulownia fortunei*. *Forests* **2023**, *14*, 207. [CrossRef]
24. Yang, H.; Xiao, X.; Li, J.; Wang, F.; Mi, J.; Shi, Y.; He, F.; Chen, L.; Zhang, F.; Wan, X. Chemical compositions of walnut (*Juglans* Spp.) oil: Combined effects of genetic and climatic factors. *Forests* **2022**, *13*, 962. [CrossRef]
25. Liu, Z.; Tan, P.; Liang, Y.; Shang, Y.; Zhu, K.; Peng, F.; Li, Y. Grafting with different rootstocks induced DNA methylation alterations in pecan [*Carya illinoinensis* (Wangenh.) K. Koch]. *Forests* **2023**, *14*, 4.