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Leaf Physiological and Wood Anatomical Responses of *Pistacia atlantica* to Simulated Dust Stress

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Abstract

This study examined the effects of simulated dust storms on Pistacia atlantica seedlings. Seedlings were exposed to dust concentrations of 5,000 to 9,000 mg/m³ over ten weeks. Results showed dust significantly inhibited wood growth, reducing annual ring width and fiber size while increasing fiber wall thickness. Higher dust concentrations decreased chlorophyll and carotenoids but increased pH, carbohydrates, and antioxidant enzyme activity. The study concludes that dust stress strongly impairs seedling wood development, providing key insights into tree physio-anatomical adaptation to dust and climate change.

Introduction

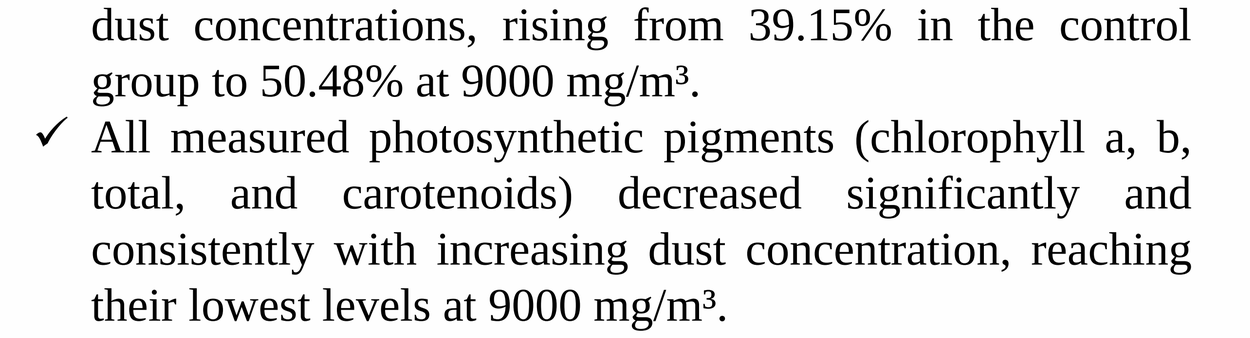
- Dust storms have intensified into a major environmental threat in regions like the Middle East and Iran.
- A significant research gap exists regarding the anatomical changes in plants caused by dust pollution.
- Dust physically blocks stomata and shades leaves, reducing photosynthesis and disrupting plant physiology.
- These disruptions lead to decreased chlorophyll, higher leaf temperatures, and ultimately reduced biomass and crop yields.
- Plants exhibit adaptive responses, such as modifying chlorophyll content and leaf structures, but these vary by species.
- The wild pistachio tree is a keystone species in Iran, making understanding its response to dust critically urgent.
- Research into its anatomical and physiological adaptations is vital for predicting resilience and guiding conservation efforts.

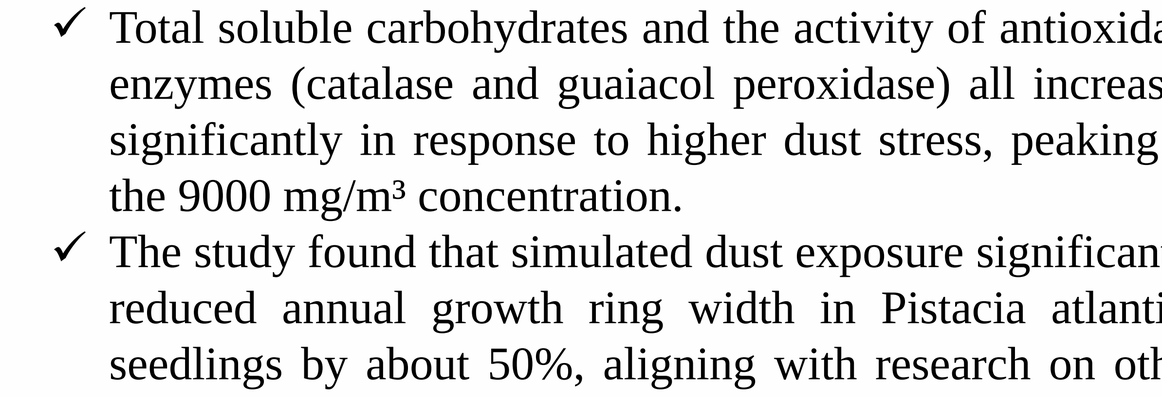
Materials and methods

- For a study, 30 two-year-old Pistacia atlantica seedlings were potted and acclimatized outdoors before being exposed to fine desert soil dust, with particles ≤40 microns in diameter.
- The seedlings exposed to simulated dust storms in a polycarbonate chamber, using three concentrations (5,000, 7,000, and 9,000 mg m^{-3}) alongside a control group. After the final exposure, leaf and stem samples were collected from all seedlings and preserved through freezing or chemical fixation for subsequent laboratory analysis.
- The Leaf, stem and root traits were measured according to the conventional methods.

Results and discussion

- ✓ Dust exposure significantly altered the wood anatomy of Pistacia atlantica seedlings, reducing annual ring width by about 50% while increasing fiber cell wall thickness by nearly 58% without affecting fiber diameter.
- ✓ While dust exposure led to a slight, non-significant increase in pH from 4.25 in the control group to 4.47 at the highest concentration, no significant differences were observed among the dust-treated groups themselves.
- ✓ Electrolyte leakage increased significantly with higher dust concentrations, rising from 39.15% in the control group to 50.48% at 9000 mg/m³.
- ✓ All measured photosynthetic pigments (chlorophyll a, b, total, and carotenoids) decreased significantly and consistently with increasing dust concentration, reaching their lowest levels at 9000 mg/m³.
- ✓ Total soluble carbohydrates and the activity of antioxidant enzymes (catalase and guaiacol peroxidase) all increased significantly in response to higher dust stress, peaking at the 9000 mg/m³ concentration.
- ✓ The study found that simulated dust exposure significantly reduced annual growth ring width in Pistacia atlantica seedlings by about 50%, aligning with research on other abiotic stresses, likely due to dust impairing water transport and limiting photosynthesis and hormone production necessary for wood formation.





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