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ASSOCIATION BETWEEN BIOINDICATION PARAMETERS OF PLANTAGO MAJOR L. AND ITS CHEMICAL COMPOSITION

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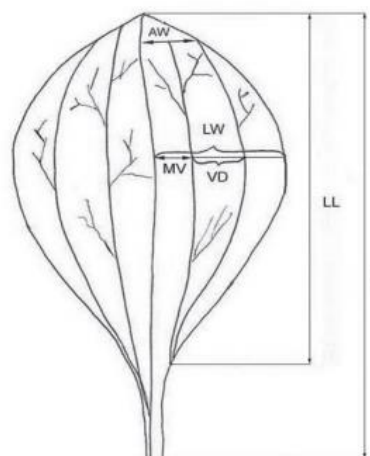


Fig. 2. Diagram of a *Plantago major* L. (sp. *major*) leaf showing leaf width (LW), vein distances within a leaf (VD), the distance from the midrib to the neighboring vein in the left and in the right side of a leaf, measured at a leaf's widest point (MV), leaf-blade apical width (AW), leaf-blade length (LL). These leaf characters are bilaterally symmetrical and only measurements of the right sides of these characters are shown in the diagram. Leaf size (LS) and width to leaf-blade length ratio (LW/LL) are also used leaf characters for numerical analysis.

Introduction

Plantago major L. is a classic subject of bioindication research. The stability of its development is used to assess the state of the environment by evaluating the level of fluctuating asymmetry (FA) – minor, non-directional deviations from the bilateral symmetry of the leaf blade. An increase in FA indicates developmental instability caused by stress.

The aim of the study is to establish a correlation between the level of fluctuating asymmetry in plantain leaves and the accumulation of specific metabolites under different anthropogenic stress conditions.

Research methods

Selection and description of the research point (Moscow, Izmaylovsky Park and Izmaylovsky Boulevard)

Collection of the leaves, labeling, storing in herbarium

Measurement of the leaves using FA method

Calculating of FA index

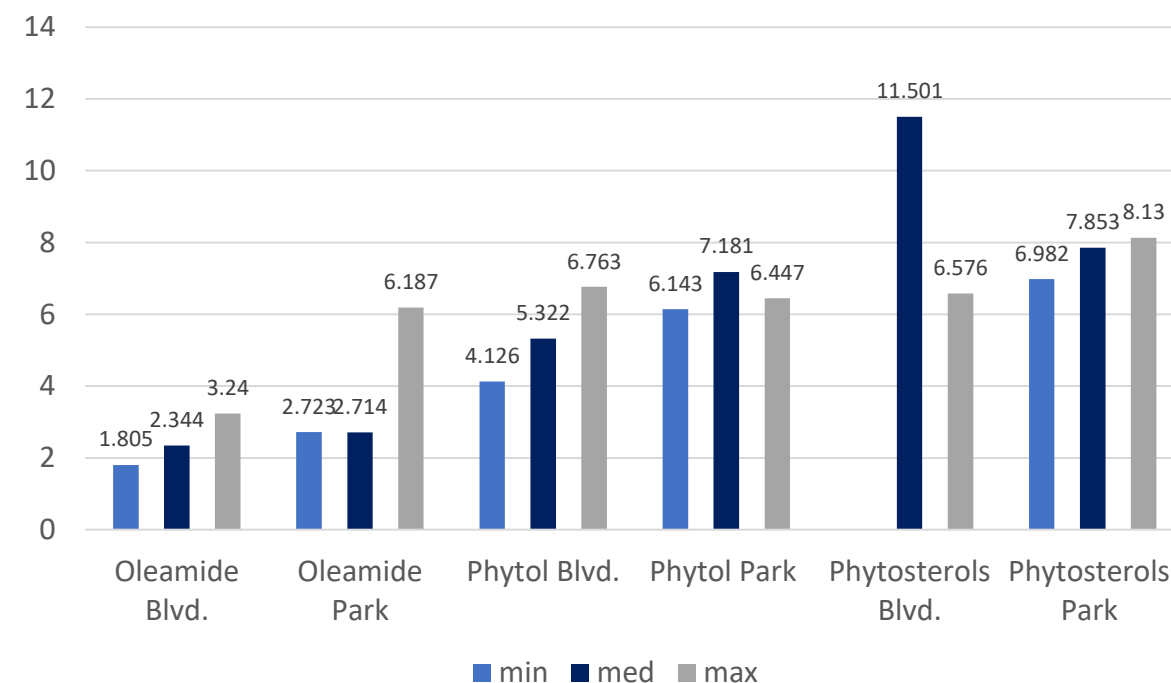
Dividing the sample into 3 fractions (min, med, max) according to FA index in each study site

Grinding, weighing fractions, preparing their alcohol solution

Studying each fraction by chromatography-mass spectrometry

Identification of compounds in the NIST-05 mass spectra library

Accumulation of substances at different sites (Boulevard and Park) of the study by fractions



Results.

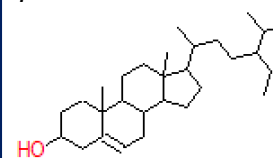
The FA index of the leaves at the Park site was 0.0629, while at the Boulevard site, where the anthropogenic load is higher, the FA index was lower at 0.0561. A total of 22 substances were detected by liquid chromatography-mass spectrometry (LC-MS) at Park, and 105 substances were detected at Boulevard.

A positive correlation was observed between FA indices and a number of compounds:

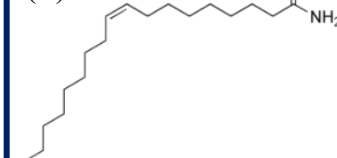
- Oleamide:** The concentration of this compound increased in the "max" fraction at the Boulevard site (up to 6.187%). This finding is consistent with previous studies that have reported the accumulation of oleamide under various stress conditions, thus supporting the proposed role of this compound in membrane protection and regulation of the microbiome.
- Phytol:** The product of chlorophyll breakdown, phytol was also found to be higher at the Boulevard site. The accumulation of phytol indicates a restructuring of metabolic pathways under stress—away from the synthesis of the important antioxidant tocopherol and towards the activation of antimicrobial (via lipid peroxidation, LPO) and signaling functions.

Phytosterols: No clear correlation with FA was found. Although an overall increase in phytosterol content was noted at the Boulevard site, the distribution of individual phytosterols across fractions showed no systemic pattern, pointing to the complex regulation of their metabolism under anthropogenic stress.

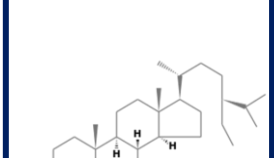
β-Sitosterol



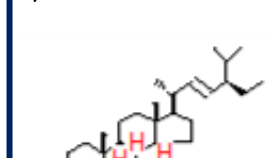
9-Octadecenamide, (Z)-



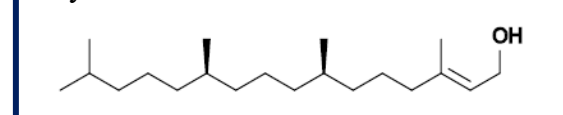
Stigmasterol



γ-Sitosterol



Phytol



Conclusion

A correlation was established between the level of fluctuating asymmetry and the accumulation of oleamide and phytol in plantain leaves. In contrast, no clear dependence on the FA level was observed for phytosterols and other identified compounds, indicating a complex nature of the plant's biochemical response to stress.