POPLARS GROWN ON ARTIFICIALLY CONTAMINATED SOILS: GROWTH AND PHYSIOLOGY

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Pilipović, A., Zalesny, R.S. Jr., Orlović, S., Drekić, M., Pekeč, S., Katanić, M., and Poljaković-Pajnik, L. 2019. Growth and physiological responses of three poplar clones grown on soils artificially contaminated with heavy metals, diesel fuel, and herbicides. International Journal of Phytoremediation. https://doi.org/10.1080/15226514.2019.1670616.

Rationale

Increasing urbanization and consequent fossil fuel usage are main causes of contemporary global climate change. One way to mitigate this problem is to use renewable forms of energy, such as biomass produced from short rotation coppice (SRC) plantations [1]. Researchers have been able to increase biomass production, and therefore cut costs of SRCs, through tree breeding and selection methods that maximize genotype × environment interactions [2]. A step further is to combine biomass production with phytotechnologies (the use of plants to clean up contaminated soils and water), for which hybrid poplar is well-adapted [3, 4]. But before any large-scale planting can occur, poplar genotypes in question must be tested to assess growth (biomass production) and physiology (related to phytoremediation potential) when grown in contaminated soils.

Objectives

- Assess the growth and physiology of three poplar clones grown on soils artificially contaminated with:
  - heavy metals, diesel fuel, and herbicides
- Compare the performance of two newly-selected clones ('Bora' and 'PE 19/66') to a commonly-used clone ('Pannonia')

Methods

Researchers used the following materials and methods for this field study:

- A plot in Novi Sad, Serbia was divided into seven subplots, one for each treatment:
  - Cd, Cu, Ni, diesel fuel, Oxyfluorfen*, Pendimethalin*, and a non-contaminated control
- Three poplar clones were planted in a split-plot experimental design and grown for three years
- Height, diameter, and physiological parameters were measured directly
- Aboveground dry biomass and instantaneous water use efficiency were then calculated
- Data were subjected to analyses of variance (ANOVA) and analyses of means (ANOM)

*herbicide

"Integrating poplar SRC with phytotechnologies such as phytoremediation offers opportunities for the production of woody biomass for energy feed-stocks with the clean-up of polluted sites such as brownfields and landfills."

- Pilipović et al. (2019)

Key Points

- Growth and physiology of poplar clones need to be tested prior to establish-ment in biomass/ phytotechnology systems
- Poplars vary in their responses to different contaminants over time

Tree Harvest
Photos by Andrej Pilipović

Physiological Measurements
Photo by Andrej Pilipović

Findings

Diameter

The clone × treatment interaction was significant in the first and second growing seasons, but not the third. Trees grown on soils contaminated with organics had larger diameters than those grown in other treatments in the first two years. Clone 'PE 19/66' had a significantly larger diameter than the other two clones during all three years.

Height

The clone × treatment interaction was significant for height in years one and three. Again, height was tallest for trees grown in the organic contaminant treatments, and clone 'PE 19/66' had the tallest trees among clones.

Biomass

Biomass was estimated using year three diameter data. The clone × treatment interaction was not significant. Trends from height and diameter (i.e., organic contaminants and clone 'PE 19/66') held true for biomass as well.

Physiology

Physiological measurements were taken in August of the first two growing seasons. The clone × treatment interaction was significant for all physiological traits in both seasons. For the parameters tested, clones varied in their responses to contaminants, performing similarly within treatments, differently, or with no discernable trends.

Conclusions

As clone × treatment interactions governed biomass production and physiological processes of the trees in this study, it can be concluded that assessing both growth and physiology are important in determining the phytoremediation potential of poplar genotypes in SRC systems. Further, the authors emphasized that it is critical to assess the effects of contaminants on concurrent physiological processes, rather than examine them separately.

Implications for the Future

- Quantifying the uptake of heavy metals was beyond the scope of this study. Future research should compare uptake with biomass and physiological parameters in order to evaluate which clones have the highest phytoremediation + biomass production potential.
- There is a need for research that explores the interactions between favorable genotypes and their rhizospheric microorganisms (known for remediating petroleum contamination [5]).
- Poplars grown in herbicide-contaminated soil showed physiological responses related to growth and development. Herbicide-tolerant poplars exist [6], but were not used in this study. Research on how resistance affects tree development over time is warranted, and comparisons potentially made between growth and development of tolerant and non-tolerant genotypes.

Sources

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