Straightening the crooked: unveiling the adaptive implications of tree stem postural control

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BACKGROUND

- Stem straightening ability affects:
  - the mechanical stability of forest trees
  - light harvesting in forest canopies
  - wood quality
- Existence of ecotypes with typically straight or crooked phenotypes is well known (Fig 1). Stem form has a strong genetic control related to differential gravitropic straightening efficiency (1).
- But, what are the **adaptive implications** of stem straightening ability? Is straightening a costly process implying differential allocation of resources?

OBJECTIVES

To study the trade-offs among traits related to resource allocation and the mechanisms implied in the straightening process comparing straight and crooked provenances of *Pinus pinaster.*

We expected a more efficient usage of resources of straight provenances compared to typically crooked ones.

1 Model species
Pinus pinaster is widely known for its extreme intraspecific variation in stem form. Straight and crooked provenances in the same provenance common garden

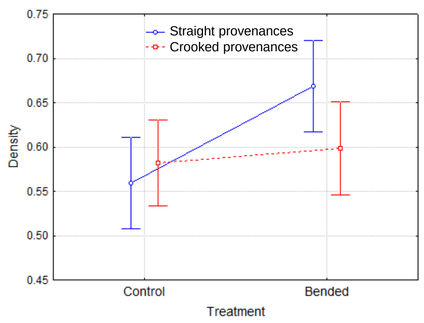
MATERIAL & METHODS

- We used a **common garden** of *P. pinaster* aged 9 years, including seven provenances chosen among those typically showing straight-stemmed and crooked-stemmed phenotypes.
- We established a **manipulative experiment** consisting in an artificial temporal bending to an inclination of 35º, and then releasing, in plants pertaining to both provenance groups. Control and bended plants were chosen considering a similar range of plant size.
- We followed the straightening kinetics and height growth after releasing and then we harvested the plants for analysing the amount of reaction wood, wood microdensity profiles, and contents of xylem carbohydrates (starch and soluble sugars) and phloem secondary metabolites (phenolics and tannins).

2 Manipulative experiment in the provenance trial: bending, release and straightening process in a tree from a straight provenance

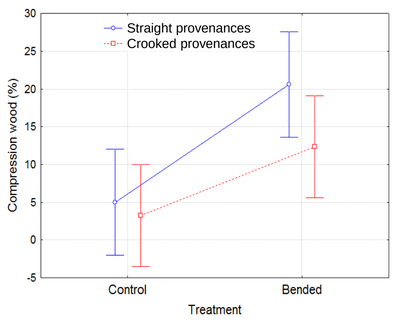
RESULTS

Wood density



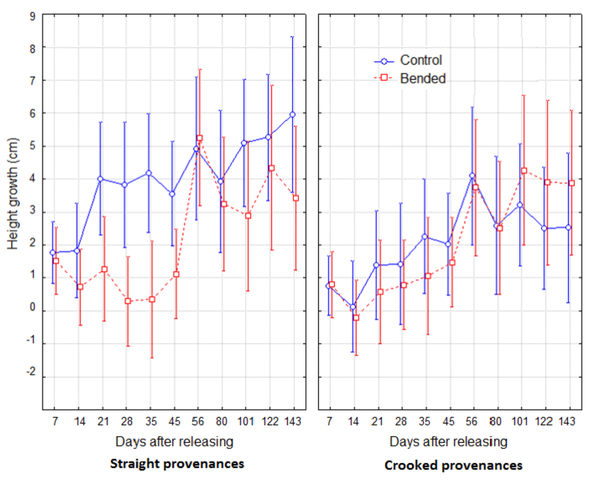
Bending involved an increase in wood density in the ring developed during the experiment, compared to the control (p=0.0431), but only in the straight provenances (p=0.0048), while the treatment did not affect the crooked provenances.

Compression wood (CW)



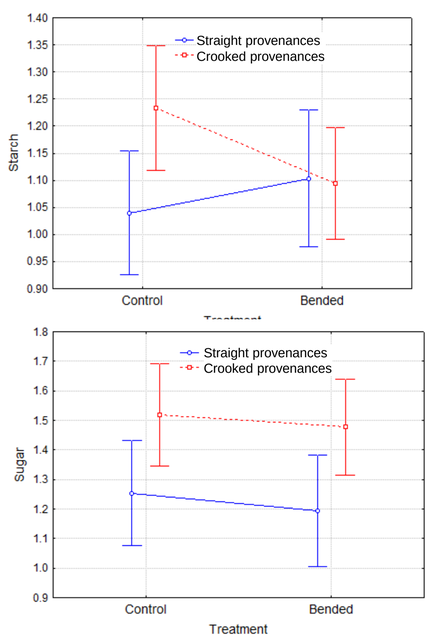
The bending treatment induced an increase (p=0.0007) in the percentage of compression wood over the total yearly ring area (%CW). Straight provenances showed %CW significantly higher in the bending treatment than in control (p= 0.0026), but for the crooked ones the treatment was not significant.

Height Growth



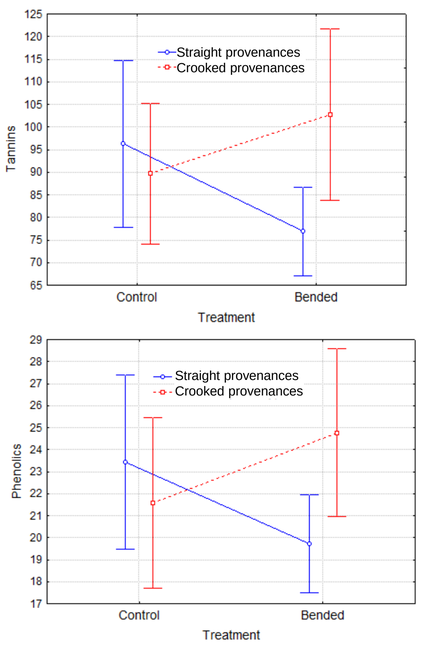
The straight provenances in the bending treatment grew significantly less than the control during the first 45 days after releasing, while in the crooked ones there was no treatment effect at any date. At the end of the experiment the differences between treatments were not significant for both provenance groups.

Non-structural carbohidrates



Starch decreased in the crooked provenances after bending but not in the straight ones (p=0.0139). Soluble sugar content was unaffected by the bending treatment, consistently higher in straight than in crooked provenances (p=0,0014).

Secondary C metabolites



In the bending treatment, crooked provenances showed higher tannin (p=0.0193) and phenolic (p=0.0265) contents than straight ones.

DISCUSION AND CONCLUSIONS

The straightening process following the bending treatment caused significant and complex changes in many traits. It was expected to be a costly process, but the strategies to attend this cost seem to be different between straight and crooked provenances. Bended straight provenances reduced the height growth, developed more %CW and (maybe as a result) more dense wood, while crooked provenances did not, although they spent starch and produced more tannins and phenolics in the phloem (a possible defensive response).

These results indicate different responses to the bending and different usage of the resources. Being compression wood development a central mechanism for stem straightening, the straight provenances displayed a more efficient strategy, probably avoiding allocating resources to secondary (putatively defensive) metabolites, and saving stored non-structural carbohydrates.

REFERENCE: (1) Sierra-de-Grado R, Pando V et al, 2008. Tree Physiology 28: 835–846. 3. DOI: 10.1093/treephys/28.6.835

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