Influence of reafforestation techniques on architectural development of the root system and on toppling in *Pinus pinaster* saplings

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Background

Aerial structure

Wind

Wind resistance

2009: Klaus storm

Standing volume 140 M m³ (1999) → 74 M m³ (2009)

soil * root system = anchorage

Roots are subjected to wind force
Schematic representation of the nine architectural compartments of the root system of maritime pine

- Shallow root
- Zone of Rapid Taper = ZRT
- Sinker root beneath ZRT
- Sinker root beyond ZRT
- Deep root
- Oblique root
- Intermediate root
- Taproot

Danjon et al., 2005
Development of maritime pine root system

Danjon & Fourcaud, 2009; Danjon & Reubens, 2008

Sapling

"guyed stake"

Adult tree

"guyed cage"

Danjon & Fourcaud, 2009; Danjon & Reubens, 2008
Development of maritime pine root system

If the circular distribution of the roots of the sapling is not homogeneous, the cage will be incomplete.

Danjon et Fourcaud, 2009; Danjon et al., 2005
Evolution of silvicultural practices

Reafforestation techniques

≠ type of tillage

Example of Strip ploughing

Planted or seeded trees

40% → 80% of planted trees
Microtopography affects
- the geometry of the root system
- the soil volume around the tree
  changing its wind resistance?

How does the microtopography influence the development of the maritime pine root system?

What are the differences in root development between different toppling levels?

Undamaged pines have a bigger and deeper taproot and also a larger volume of roots, leeward and windward.

How does the establishment (seeded or planted trees) influence the development of the maritime pine root system?
Choice of observation stands

Seeds

Full ploughing

Rotary ploughing

Planted trees

Strip ploughing
damaged by Klaus Storm in 2009

In each stand 9 trees

- # # Undamaged trees
- /// Leaning trees
- //// Toppled trees

Same tree dimensions
uprooting of (9 x4) root systems
3-D digitizing of root systems
3-D digitizing of root systems

Volume in each compartment
Total volume

Analysis of variance on 300 variables
RESULTS: Inventory of damage at stand level

There are more undamaged trees on "planted, full ploughing" stand than on "planted, rotary ploughing" and "planted, strip ploughing" stands.

There are more toppled trees on the "planted, full ploughing" stand than on "seeded, full ploughing" stand.
RESULTS: Microtopography measures around the selected trees

Microtopography comb

average altitude variance of the 6 radius perpendicular to the tree line for each selected tree

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<tbody>
<tr>
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<td>Seeded Full ploughing</td>
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<td>Planted Rotary ploughing</td>
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<td>Planted Strip ploughing</td>
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Legend:
- U: Undamaged tree
- L: Leaning tree
- T: Toppled tree
RESULTS: Undamaged / Toppled trees

Windward  Undamaged trees  Leeward

No reinforcement

Reinforcement in
Root volume
Number of roots

Orders 2

sinkers beyond ZRT

deep roots *

For the undamaged trees
Not the same reinforcements leeward
RESULTS: Planted / Seeded trees

Planted trees

More roots on the stump
+65.5%

but same root volume
finer shallow roots
-31.6%

Taproot thinner and deeper
volume: -32.2%
depth: +12.4%

Bigger stump
volume: +24.9%
RESULTS: Tillages

- Strip ploughing/Full ploughing:
  - Deep roots: -33%
  - Intermediate and oblique roots: +72%
  - Roots nb: +64%

- Rotary ploughing/Full ploughing:
  - Volume of taproot: +44%
RESULTS: Principal component analysis (PCA) of tree characteristics

- 1st component (19.0% of variance)
- 2nd component (15.2% of variance)

- ZRT Volume % stump Volume %
- volume of deep roots %
- volume of Taproot %
- volume of leeward roots %

Legend:
- Undamaged trees
- Leaning trees
- Toppled trees

Toppling levels
Differences in the reinforcement between planted trees and seeded trees could be explained by morphology differences.

**Planted trees**
- bigger stump,
- numerous thinner shallow roots

**Seeded trees**
- bigger taproot,
- thicker shallow roots

**Discussions**
- not the same biomass distribution
- several optimal root systems resisting to the wind
- BUT
- same percentage of undamaged trees
Differences in the root system of trees from different tillages

Only few differences between the 3 tillages

Trees of rotary ploughing stand have a bigger taproot better planting bed?

Volume and number of intermediate and oblique roots in the strip ploughing Injuries by mechanical weeding

No differences linked to toppling level

Ditch of the strip ploughing wind direction

It would be interesting to have a ditch perpendicular to wind direction
According to tree size, the mechanical design of root system changes.

For 8m trees

- the influence of windward roots in the stability is limited
- there is reinforcement in leeward roots

explained by the properties of sandy soils

Windward roots can easily lift up without resistance

Guyed cage not efficient
Thanks for your attention

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