Resilience from perturbation of architectural scheme through planting varies largely in Pinus pinaster

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Introduction: Planting is a widespread propagation technique for woody plants. Container-growth and plantation is likely to heavily alter root architecture and thus modify anchorage.
The Landes forest is located South-West France and produces 20% of french wood, it is mainly composed of intensively managed even-aged stands of *P. pinaster* (Ait). Most reforestation is made by planting genetically improved varieties, from seeded nursery stock. Soils are entic to albic spodosols which are acidic, sandy, and lenses of cemented spodic horizon can occur.
Root system architecture is a key component in mechanical stability of trees. In their first 15 years, pines are mainly anchored by a rigid vertical and deep taproot (Danquechin Dorval 2016). Older trees are anchored by a rigid cage mainly composed of regularly spaced strong shallow roots from which branch secondary sinkers (Danjon et al. 2005). The main framework of the central part of the root system is established at 4-years-old with a clear identification of root types (Saint Cast et al. 2020).
In this study, we characterize the deformations of root systems of *P. pinaster* saplings grown in containers and planted in the field. Incidence on root system architecture is analysed.

MATERIAL AND METHODS

Three hundred 3 to 5-years-old *P. pinaster* saplings planted in 16 forest stands were uprooted with hand tool and digitized using a magnetic field Polhemus 3D digitizer (Danjon & Reubens 2008). They were compared to 30 direct seeded trees from one stand. The resulting database contained 67000 segments and 10250 axes.
We set up and used an original architectural analysis to characterise deformations and thus root type modifications in order to examine the resulting root architecture and potential stability.

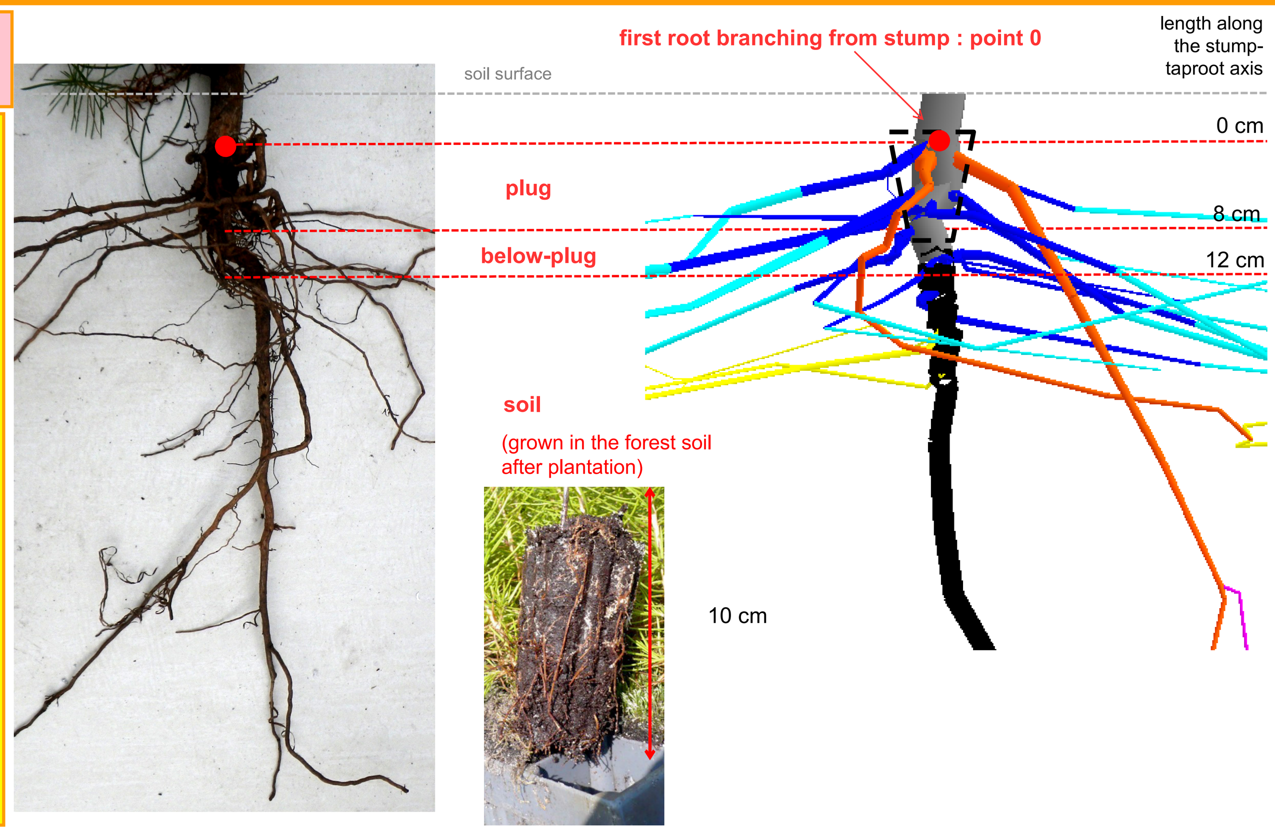

Fig 1: Spatio-temporal landmarks on the stump-taproot axis

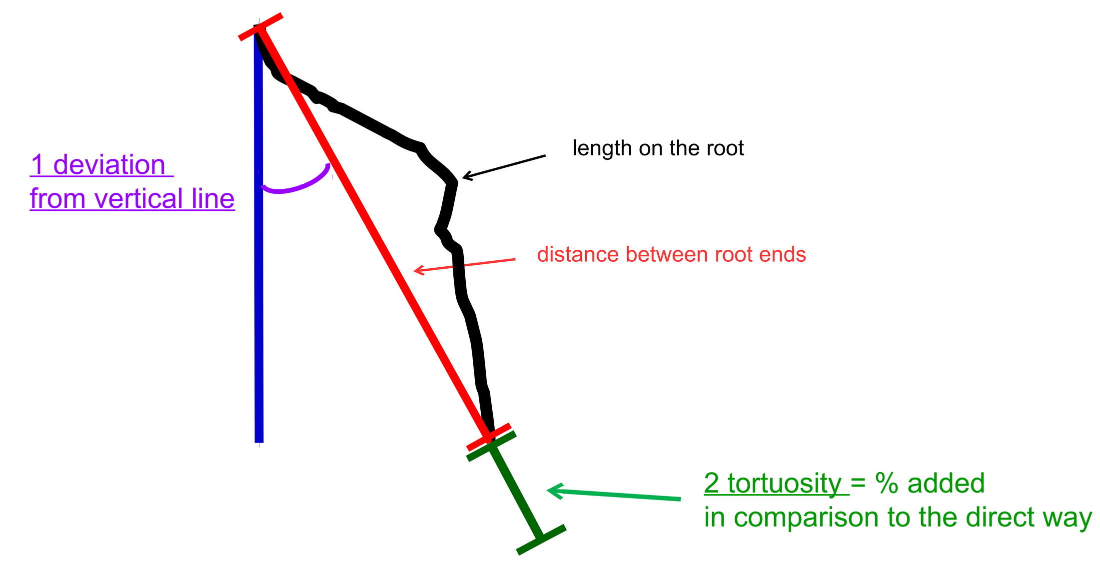

Fig 2. Variables of deformation on the stump-taproot axis

Between the base of the root and 6 cm radial distance, calculation of azimuth variation (in degrees)

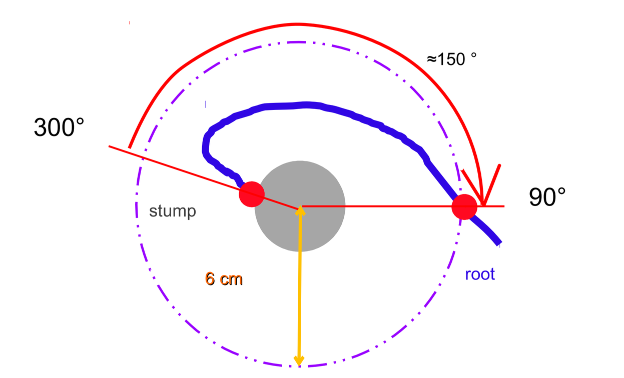

Fig. 3: Variables of deformation of the shallow roots branching from stump, Two other variables are calculated: sum of radial distance (tortuosity %) and Depth (cm) variations from the base of the root and 6 cm radial distance the

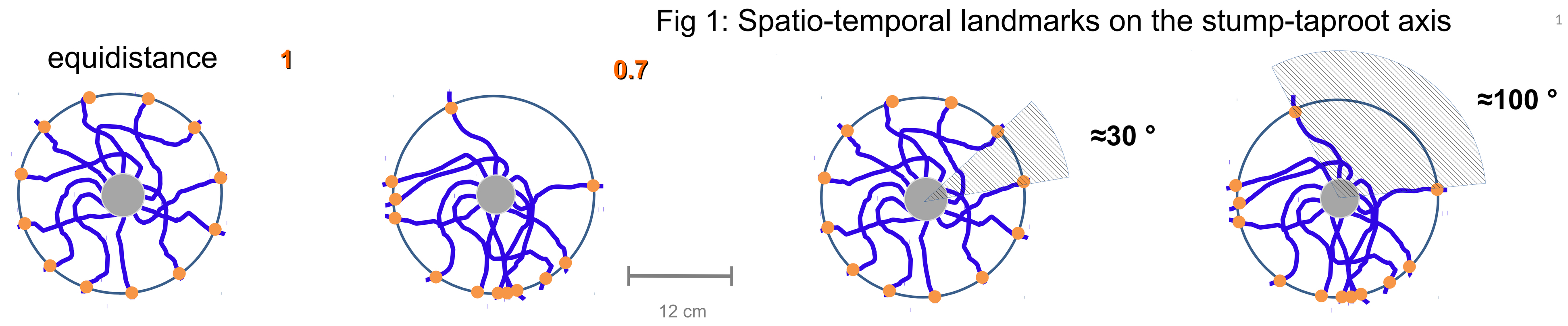

Fig. 4: Variables reporting for circular distribution of shallow roots at 12 cm radial distance. Left: a clustering index defining root grouping (sum of distances / sum when equi-distances) Right: Largest angle between shallow roots (LABS)

RESULTS

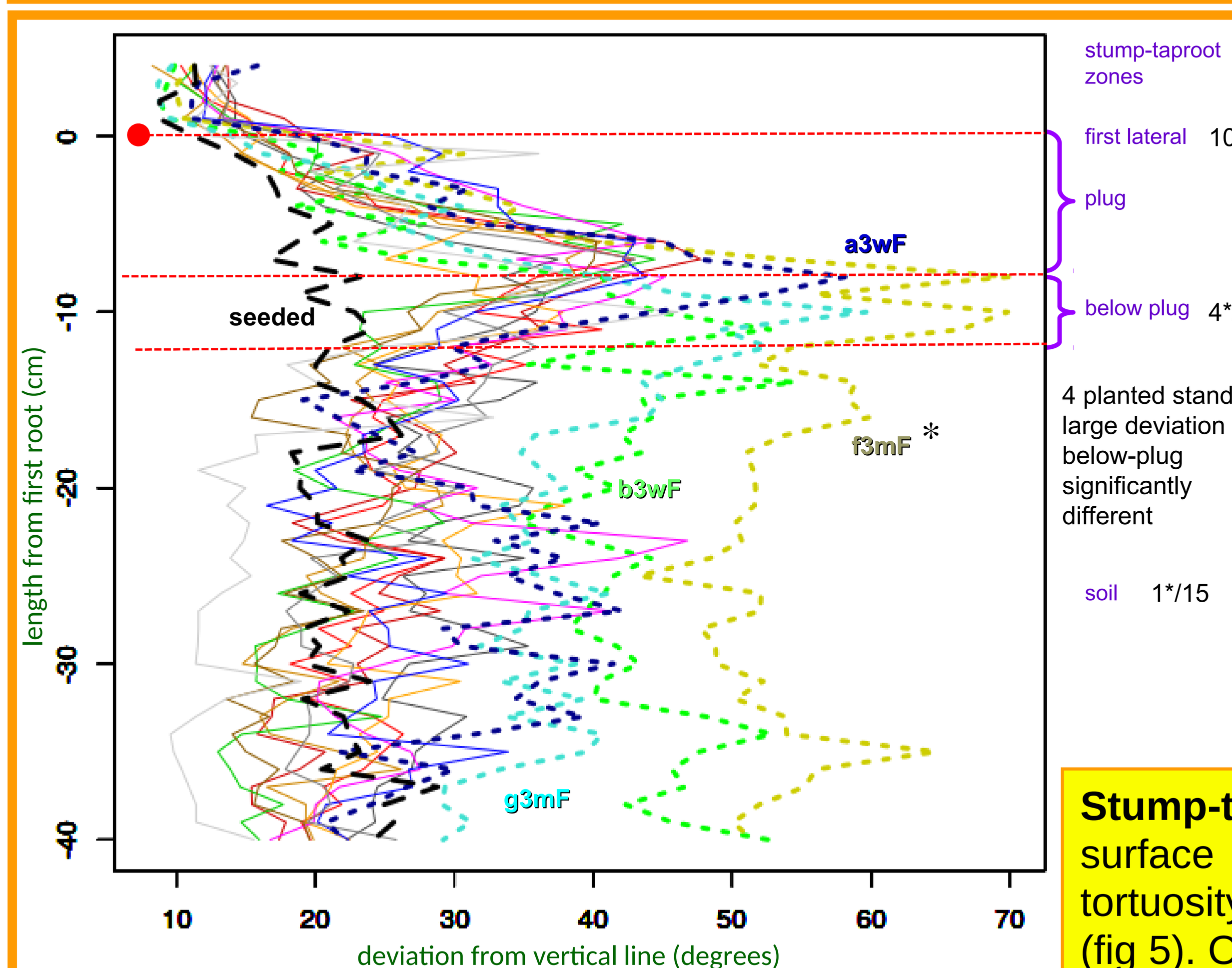

Fig. 5: Vertical deviation of stump-taproot axis every centimetre. Black dotted line is for the seeded trees.

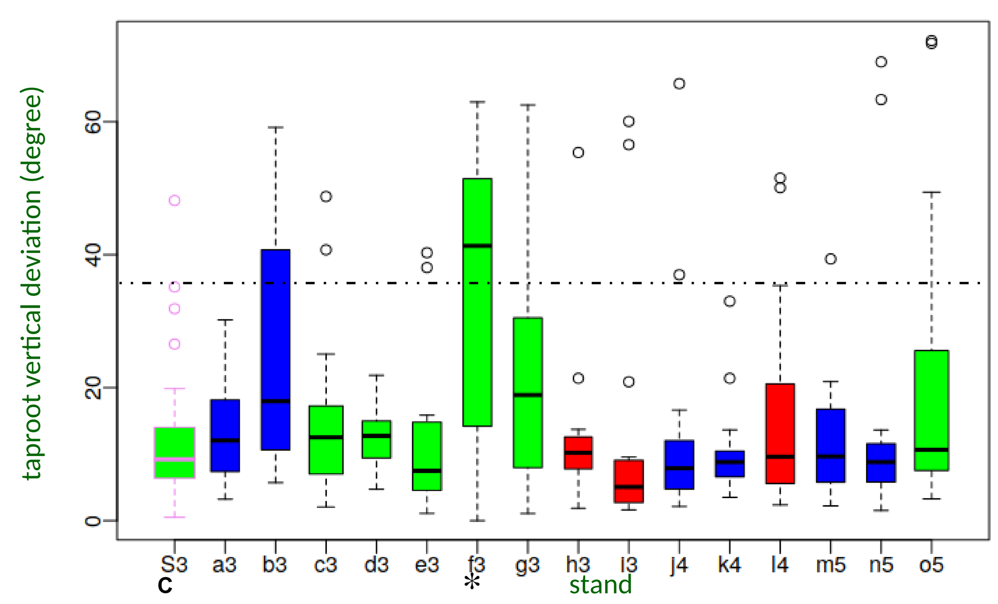

Fig. 6: Boxplot per stand of taproot vertical deviation. "*" when significantly different from the seeded control (C)

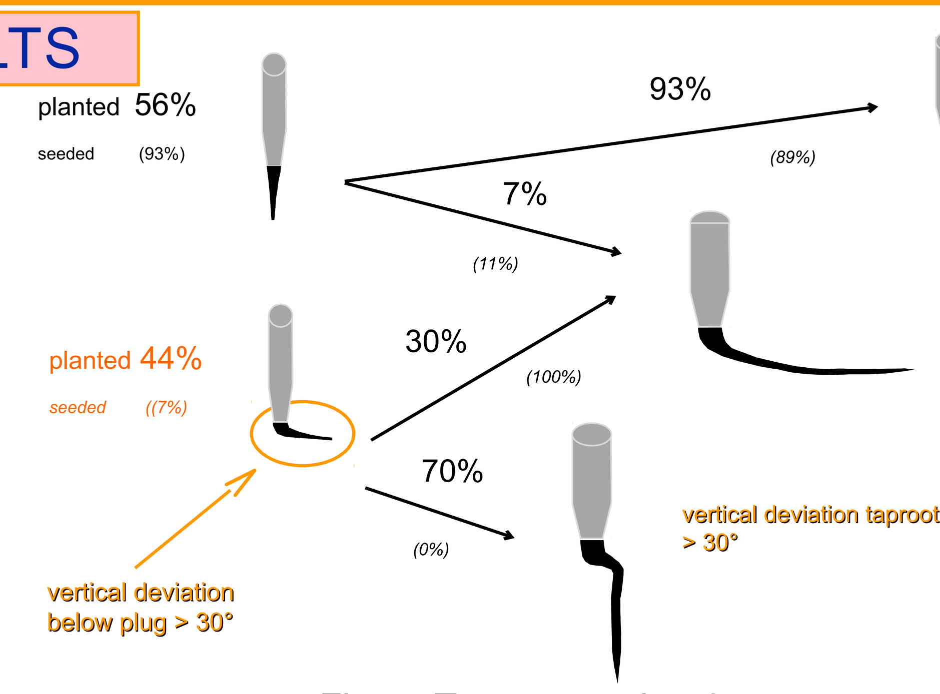

Fig. 7: Taproot tropism loss.

Stump-taproot axis: The root system of planted trees was 1.8 cm deeper on average than seeded trees, few plugs showed on the soil surface or were crushed. Plug tortuosity averaged 14% in the planted trees and 5% in the seeded trees, below plug and soil zone tortuosity was weak. In the below-plug zone, vertical deviation of the first order root peaked at a 40° average vs. 20° in the seeded trees (fig 5). Overall, 17% of planted trees have a non vertical taproot vs. 1.5% for the seeded (fig 6). When the taproot was not vertical in the 4 cm long below-plug zone, 30% of the taproots did not recover their verticality. Conversely, only 7% lost it when the below plug zone was vertical (fig 7).

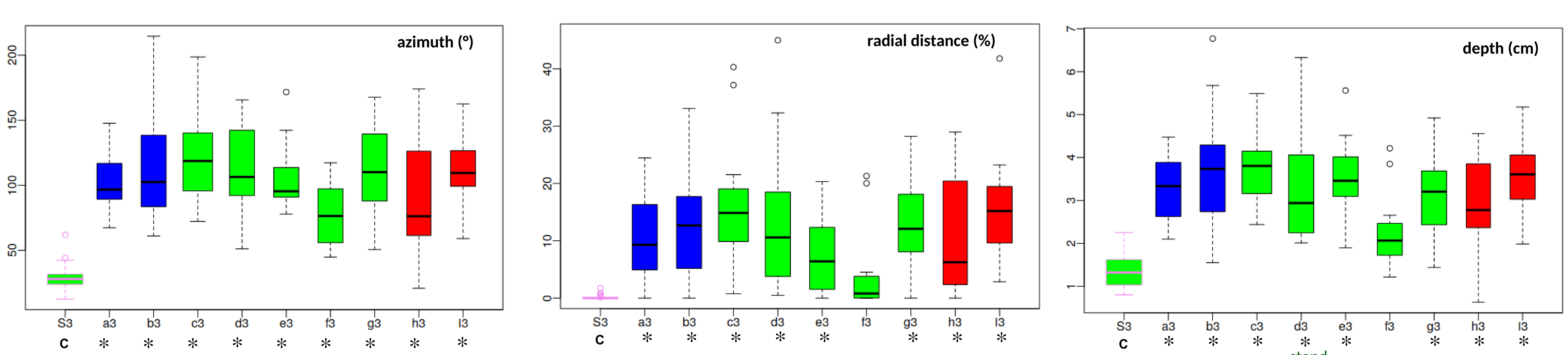

Fig. 8: Boxplots per stand of deformation of roots branching from stump

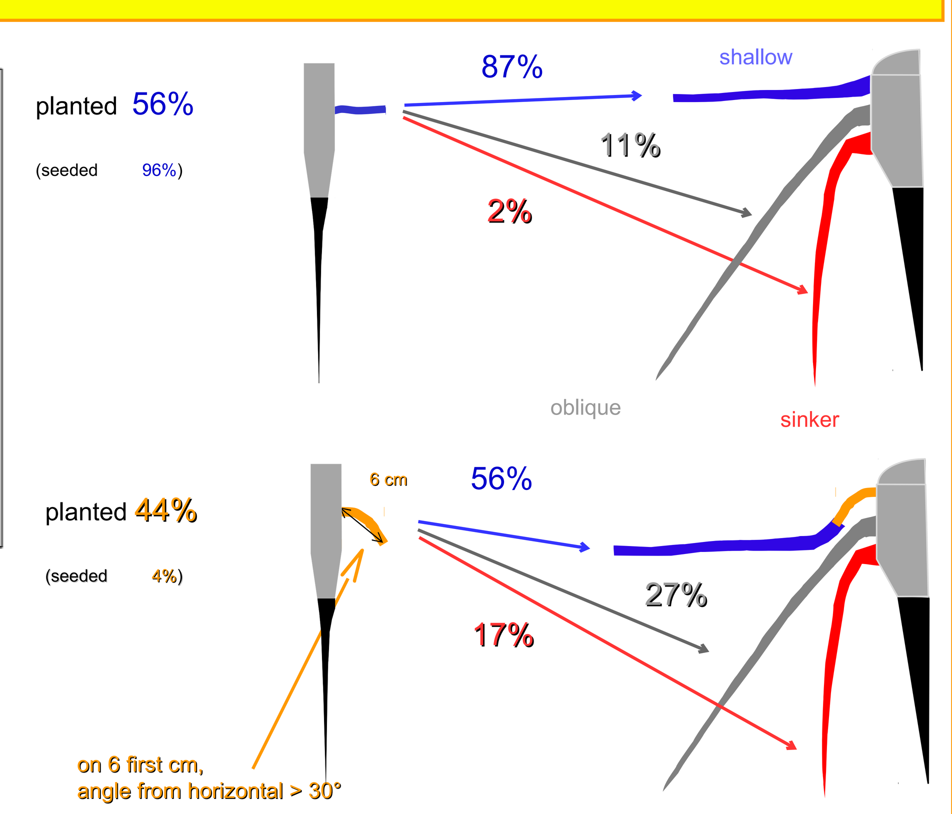

Fig. 9: Tropism loss of roots branching from stump (2700 roots in 3-years-old trees).

Potential shallow roots: The distribution of these roots along the first order root was not modified by container planting and the largest ones grew from the upper plug zone. Heavy deformations of laterals due to nursery growth in grilled and vertically grooved containers and by planting were located within 6 cm radial distance from the taproot (fig 8). When the 6 first cm of a lateral root was maintained in a non-horizontal position, 27% of these originally shallow roots grew as oblique roots and 17% as sinkers. Conversely, when horizontal at base, 89% of the lateral roots remained shallow (fig 9). The largest azimuth angle between shallow roots (LABS) is mainly determined by their number at 12 cm radial distance from the first order root (ρ = 0.7), which is lowered when shallow roots lose their plagiogravitropism (fig 10). Ten planted stand showed significantly larger clustering of azimuth of their shallow roots resulting in significantly larger angle between shallow roots (ρ = 0.84).

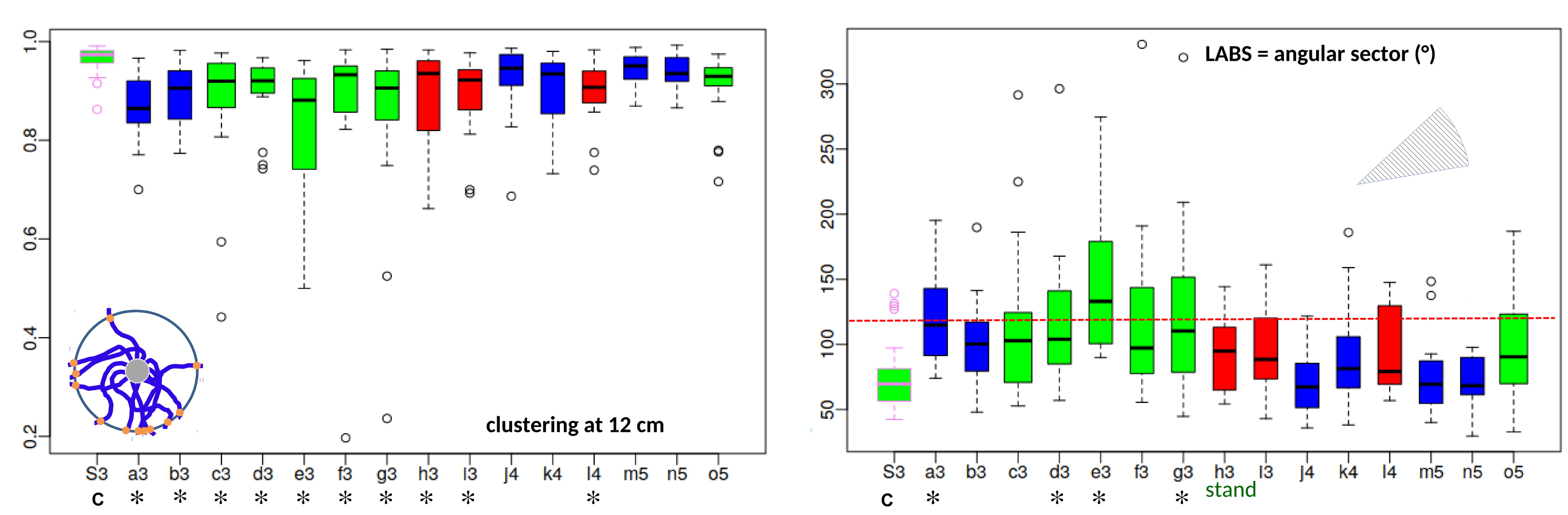

Fig. 10: Boxplot per stand of circular distribution of shallow roots

Conclusions: The studied planted stands showed low mortality and a small number of badly planted seedlings. They displayed a very large variability in type and degree of deformations which could not be related to variables like the planting season or the type of soil preparation. About half the planted trees showed a good resilience as they were able to grow a root system which is likely to provide a good anchorage, other trees posses a non-vertical or weak taproot or show large LABS, except in planted stands b3, e3 and f3 where less than 20% of the root systems has no unacceptable defect We concluded that change in root tropism through nursery growth, planting and initial root regrowth is likely to weaken the anchorage of the trees both in juvenile or mature stage. Thus orientation of root ends at interface of the plug and the soil, just after plantation is a major issue for tree anchorage.

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