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Influence of containers on root development after transplantation on different provenances of *Pinus pinaster* Aiton using rhizotrons.

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Introduction:

Although most of the planting carried out worldwide continues to be done by direct seeding, for economic reasons reforestation with container plants is particularly interesting in the Mediterranean region and is most often used in some countries like Spain. The container used in the nursery has a great influence on the morphology and subsequent root development, affecting both the development and survival of plants and its stability (Sundstrom & Keane 1999; WATSON & Tombleson 2002). Rooting depth as well as structure and distribution of roots have been shown to be closely related to adaptive strategies in different biomes globally (GUERRERO-CAMPO & FITTER 2001). The differences in radical formation, the highest root density and the presence of twisty roots in the containers with respect to natural regeneration has been associated with a reduced capacity of root production in field soil, especially the lateral ones and with a plant architecture which is highly different from those regenerated by direct seeding (Grene, 1978; HALTER and CHANWAY, 1993). Once transplanted, the less developed root system of container-grown plant in the field may reduce the structural stability (Lindstrom and Rune, 2000) and growth of trees.

Given the great variability that *Pinus pinaster* provides in virtually all morphological and adaptive characters, it also seems safe to assume that there is natural variability in the capacity to generate roots with different effectiveness for anchorage.

The objective of this experiment is to study the rate of root growth and its spatial distribution during the first year of life over two provenances of *Pinus pinaster*, comparing plants grown in containers and then transplanted with plants grown from seeds (natural regeneration). Monitoring was carried out periodically through rhizotrons as a method of non destructive continuous observation.

Methodology:

We used a total of 36 rhizotrons with plants of provenances of Gredos and Oña. For each provenance, half the plants were obtained through direct seeding and the other half through containers. The experimental design was randomized blocking.

Seeding was carried out for both treatments on September 19, 2010 in Maceda (Ourense), Autonomous region of Galicia (Spain). Container crop treatment and later transplantation was performed by attaching containers longitudinally open, filled with substrate to the rhizotrons forespot 150 cc so that the Rhizotron glass limited half of the container. At the end of the first growing season in March 2011, half container was taken out and the rest of the Rhizotron was filled with substrate, thus simulating a transplantation to the ground. The direct seeding treatment was performed on the Rhizotron placed in the same position.

The trial for the two treatments was conducted entirely outdoors with a duration of one year. The rhizotrons were made of white painted sheet metal to avoid overheating, dimensions were 100x30x10 cm (Riedacker 1974), reaching a volume of 30 litres with a movable side to observe the roots. They were tilted 30 degrees from the vertical to ensure the growth of the root attached to that face due to geotropism.

The sampling frequency was set at 40 days according to (Joslin and Wolfe, 1998). To study the growth of the roots, these were copied on acetates using permanent markers in different colours depending on dates of control, so that it was possible to collect all the information for later processing into cabinet. This technique has been the same as that used by (Grieu et Aussenac 1988) to follow the growth and development in seedlings of three conifer species.

The root length was measured with a curvimeter and the angle of insertion of secondary roots with respect to the tap root with a conveyor. Similarly, height and diameter on the aerial part were measured using tape and a caliper respectively.

The parameters analyzed were :

Aerial parts

- Height of plant
- Diameter at neck insertion
- Presence/ absence of terminal buds
- Number of needles per plant

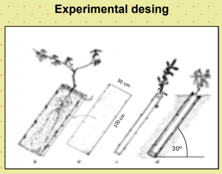
Underground part

- Length of tap root
- Length of secondary roots
- Taproot atrophy
- 1st and 2nd secondary root angle
- Total root length according to seeding and provenances
- Rate of colonization according to seeding and provenances

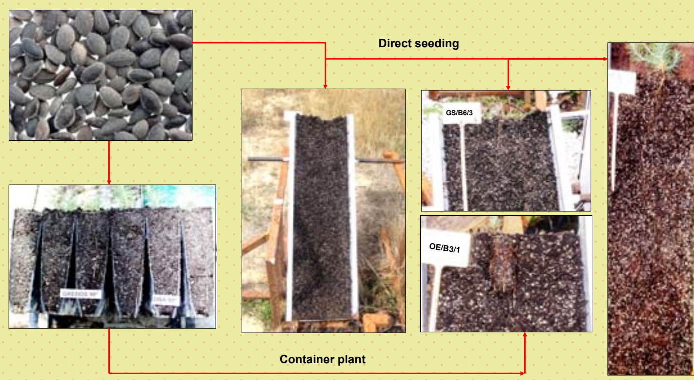
Rizo6	GS	OE	GS	OS	GE	OS
Rizo5	OE	GE	OS	OE	GS	GE
Rizo4	GS	OS	GS	GE	OE	OS
Rizo3	OS	GE	OE	OS	GE	GS
Rizo2	GE	OS	GE	OE	GS	OE
Rizo1	OE	GS	OE	GS	OS	GE
	Bloque 1	Bloque 2	Bloque 3	Bloque 4	Bloque 5	Bloque 6

Gredos semilla | Gredos envase | Oña semilla | Oña envase

Experimental desing



Rizotron; Riedaker A. 1974



Results and discussion:

A repeated measures ANOVA was performed for the analysis of variance.

On the aerial part, no significant differences between treatments in any of the parameters studied were noticed, probably because of the short period of time for analysis which was of one year.

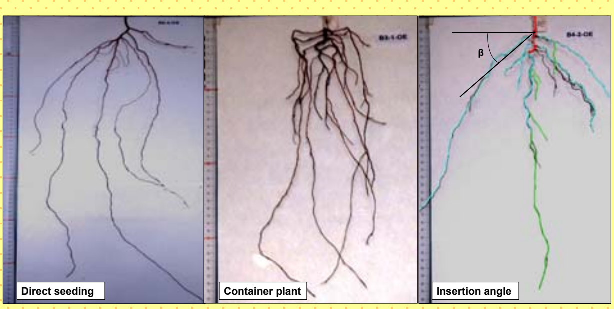
Significant differences in the atrophy of the tap root were found in the root system, being greater in container plants, probably due to planting out. No differences were found among provenances.

The tap root growth in seed plants is significantly higher pv <0.0038 compared to plants from container during the entire sampling period.

However, there are not significant differences in growth at any stage of the experiment regarding secondary roots length.

Provenance has not been a significant factor in any of the variables studied, nevertheless, a significant effect on the angle of insertion of secondary roots is seen, having the Oña provenance in container a smaller angle than the same one through direct seeding. In Gredos plants, this effect does not appear.

Finally, the rate of root colonization until the July control has been significantly lower in container plants than in direct seeding . From this time on, the two treatments are equal in terms of the root surface that the Rhizotron occupies.

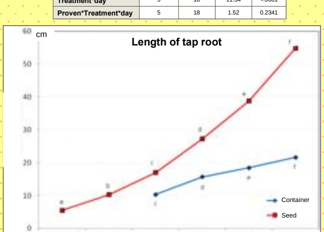


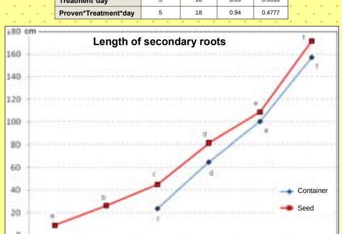
Length of tap root				
Effect	Num DF	Den DF	F-Valor	Pr > F
Block	5	18	3.38	0.0250
Provenance	1	18	0.33	0.5723
Treatment	1	18	31.51	<.0001
Provenance*Treatment	1	18	4.43	0.0496
Control day	5	18	35.07	<.0001
Provenance*day	5	18	0.57	0.7254
Treatment*day	5	18	11.34	<.0001
Proven*Treatment*day	5	18	1.52	0.2341

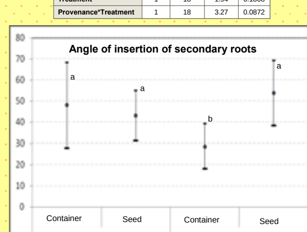
Length of secondary roots				
Effect	Num DF	Den DF	F-Valor	Pr > F
Block	5	18	4.21	0.0104
Provenance	1	18	0.24	0.6290
Treatment	1	18	1.93	0.1819
Provenance*Treatment	1	18	0.73	0.4041
Control day	5	18	28.67	<.0001
Provenance*day	5	18	1.96	0.1343
Treatment*day	5	18	6.09	0.0018
Proven*Treatment*day	5	18	0.94	0.4777

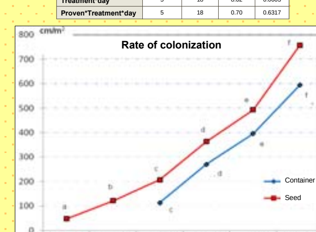
Angle of insertion of secondary roots				
Effect	Num DF	Den DF	F-Valor	Pr > F
Block	5	18	0.48	0.7887
Provenance	1	18	0.21	0.6508
Treatment	1	18	1.94	0.1808
Provenance*Treatment	1	18	3.27	0.0872

Rate of colonization				
Effect	Num DF	Den DF	F-Valor	Pr > F
Block	5	18	4.77	0.0060
Provenance	1	18	0.08	0.7746
Treatment	1	18	6.13	0.0235
Provenance*Treatment	1	18	1.52	0.2331
Control day	5	18	40.26	<.0001
Provenance*day	5	18	1.70	0.1849
Treatment*day	5	18	8.62	0.0003
Proven*Treatment*day	5	18	0.70	0.6317









Conclusions:

It is obvious that the container causes a root system morphology that is completely different from which is produced naturally. See pictures.

Normally, container grown plants produce root systems that are less symmetrical than the naturally seeded. This is especially important in young plantations but tend to disappear in adult plantations (LINDSTRÖM and RUNE, 2000).

In general, the root system in both treatments is developed densely and with a homogeneous spatial distribution within the Rhizotron, which allows them to adapt perfectly to the environmental conditions of post transplanting. This may lead to a better morphological balance to increase survival and stability of the plantations.

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