ResAlliance

Type of solution: Management Sector: Agroforestry, Forestry
Good practice(s): Soil management, Management alternatives

Stone pine grafting with alternative rootstock species and grafting approaches: an alternative to increase the potential production area of stone pine nuts

Results from a 12-year experiment contributing to a more versatile land use and with multiple benefits in the domain of Stone and Aleppo pines in Os de Balaguer (Lleida, Spain).

Aspect of the plantation in 2012.
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mage of a successfully grafted tree.
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/// Context ///

The Mediterranean Stone Pine (*Pinus pinea*) is a species of high productive and ecological interest in the Mediterranean region, particularly known for its highly prized edible nut. The grafting technique makes it possible to anticipate and significantly increase nut production, resulting in a growing interest in this species as a forest fruit tree. In addition, grafting onto Aleppo pine (Pinus halepensis) rootstocks significantly increases the potential production area of stone pine nuts.

We describe the process of design, implementation, maintenance, and production results of a stone pine plantation installed at the beginning of 2012 with a triple objective:

- Nut production.
- Prevent land abandonment and maintain a mosaic agroforestry landscape.
- To generate research and knowledge transfer on the use of different rootstocks (Aleppo pine – *Pinus halepensis* vs. Mediterranean Stone Pine – *Pinus pinea*) and grafting approaches (nursery vs. field grafting vs. no grafting).

This plantation was established by the Forest Science and Technology Centre of Catalonia (CTFC) on private land, as part of the AECI-PCI project “Production and management techniques of stone pine (*Pinus pinea*) for early pine production: plantations planted as an alternative for the restoration of degraded areas and the generation of income in rural communities”. In recent years, monitoring has been carried out under the MasPineNut project “Making sustainable the stone pine production by its management as nut tree” (2020-2024), led by IRTA and CTFC.

/// Solution for a Resilient Future ///

The Mediterranean stone pine is characterised by its multifunctionality, both productive (highly valued pine nut, timber), ecological (restoration of sandy soils) and social – a species characteristic of the Mediterranean landscape, with a particular conformation, with an umbrella-shaped crown.

The aim of this experimental and demonstration plantation, which covers almost one hectare and was planted in Os de Balaguer (Lleida province) in the winter of 2011-2012, is threefold:

1. Production of pine nuts: to produce a nut with a remarkably high market price, averaging 60€/kg between 2020 and 2023 (DACC, 2024).
2. Preventing the abandonment of a small agricultural plot and maintaining a mosaic landscape.
3. Experimental: to generate knowledge on the effect of grafting (evaluation of nursery grafted trees, field grafted trees and non-grafted trees) and on the use of rootstocks of different species (Mediterranean stone pine and Aleppo pine) on survival and cone production.

The number of experimental trees is:

- Stone pine rootstocks (70) vs Aleppo pine rootstocks (70).
- Nursery grafted (44) vs field grafted (68) vs not grafted (18).

In the different treatments, three complete randomised blocks were distributed. A total of 140 trees were planted in a 5 x 5 frame.

Soil preparation consisted of deep subsoiling (50 cm) and manual opening of pits (30 x 30 x 30 cm). At the time of planting, black polyethylene mulch (100 x 100 cm) was placed on each tree to prevent competition from spontaneous vegetation and individual 60 cm black mesh protectors to prevent damage from fauna. The perimeter of the field was

	Kernel biomass per tree, 2021 (g)	Equivalent gross income, 2021 (€/ha)*	Kernel biomass per tree, 2022 (g)	Equivalent gross income, 2022 (€/ha)*
P. halepensis, field grafting	423.9	1,017	67.8	163
P. halepensis, nursery grafting	511.8	1,228	48.5	116
P. pinea, field grafting	39.9	96	26.0	62
P. pinea, nursery grafting	114.4	275	25.3	61
P. pinea, not grafted	2.6	6	7.6	18

* Based on 400 trees/ha with this treatment, and the average market reference price of 60 €/kg.

protected by a 150 cm high fence. Nursery grafting was carried out in April 2011 and field grafting in April 2012.

Maintenance consisted of low pruning in 2012, 2014 and 2020 to prevent rootstock branches from dominating the canopy, annual or bi-annual pruning and cutting of Aleppo pines where grafting was unsatisfactory and replacing them with new stone pines (20). Finally, in 2022 and 2023, *Leptoglossus occidentalis* (western conifer seed bug) was treated with deltamethrin (40 ml/100 l of water; application of 150-180 l), applied with a sprayer and elevator.

The variables measured, with varying periodicity, are:

- Survival and vegetative state.
- Basal diameter.
- Total height.
- Number of cones of different ages, in summer and winter (2021-23).
- Pine nut production and kernel:cone ratio (2021-23).

The main results of the plantation are as follows:

- Mortality was 5% in Aleppo pine rootstocks and 13% in stone pine rootstocks. No differences were observed between trees grafted in the nursery or in the field.
- Productivity, both in terms of cones 2021-23 and biomass, shows a yield superiority of trees with Aleppo pine rootstock. In 2021, the income per hectare of pines grafted with Aleppo pine rootstock exceeded 1,000 €/ha, a very promising figure considering the age of the plantation (11 years).
- The non-grafted pine trees are clearly the least productive, with only 17% of the trees starting to produce cones.
- Finally, the kernel:cone ratio was 5.0% in healthy cones and 3.6% in cones damaged by *Leptoglossus occidentalis*.

Panoramic image of the stone pine plantation in Os de Balaguer.
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Plantation monitoring measures during 2023.
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/// Always Moving Forward ///

Wild animals feeding and domestic grazing on acorns can slightly alter the values presented above. Estimates of acorn availability can be improved and made more robust by continuing the acorn inventory for several years in a row. Linking acorn availability values with meteorological data, forest stands and soil characteristics, could provide relevant information on acorn availability as a function of the above variables, and contribute to new silvicultural approaches for multipurpose management of Pyrenean oak stands.

Acorn harvesting is essentially manual, which makes the process time consuming and costly, and there is a shortage of labour in the interior regions. Mechanical harvesting technology is underdeveloped, although some attempts have been made to adapt equipment used for other crops such as olives and chestnuts. In the future, equipment and technology may be developed or harvesting methods improved to speed up the process and make harvesting more economical.

By investing in research and continuing to collect data, it will be possible to improve the estimates of acorn prediction models, as well as improving forestry models in terms of acorn availability.

The acorn value chain needs to be improved through the development of food products and the associated marketing of products containing acorns.

Further information

- Beltrán, M., Pallarés, M., Coello, J., Busquets, E., Piqué, M. 2022. Gestión de las masas y plantaciones de pino piñonero en Cataluña y los Pirineos Orientales: viabilidad de producción de piñón. Quality Pinea Project. 52 p. https://es.qualitypinea.eu/_files/ugd/774dfb_4c46091bb44c426eb764740322b51863.pdf (In Spanish)
- Departament d' Acció Climàtica, Alimentació i Agenda Rural. 2024. Seguiment mercat internacional: pinyons. Generalitat de Catalunya. https://agricultura.gencat.cat/web/.content/de_departament/de02_estadistiques_observatoris/20_observatori_agroalimentari_de_preus/03_preus/01_preus_en_origen/seguiment-mercat-internacional/fitxers-binaris/Pinyons.pdf (In Catalan)
- De la Mata, R., Teixidó, A., Aletà, N., Torrell, A., Ros, L., Segarra, M. 2019. La producció de pinyons en plantacions empeltades. Resultats dels assaigs instal·lats a l'IRTA. Catalunya Forestal, 142, 5-10. https://www.forestal.cat/bdds/imatges_db/revistes/document_1/REVISTA_3366300015762543.pdf (In catalan)
- Guàrdia M, Teixidó A, Sanchez-Bragado R, Aletà N (2021). An agronomic approach to pine nut production by grafting stone pine on two rootstocks. Agriculture 11: 1034. https://doi.org/10.3390/agriculture11111034
- Piqué, M., Coello, J., Ammari, Y., Aletà, N., Sghaier, T., Mutke, S. 2017. Grafted stone pine plantations for cone production: trials on *Pinus pinea* and *Pinus halepensis* rootstocks from Tunisia and Spain. In: Carrasquinho, I., (ed.), Correia, A.C., (ed.), Mutke, S. (ed.). Mediterranean pine nuts from forests and plantations. Zaragoza: CIHEAM. p. 17-23. (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 122). 2. International Meeting on Mediterranean Stone Pine for Agroforestry : AgroPine2016, 2016/05/18-20, Oeiras (Portugal). https://om.ciheam.org/om/pdf/a122/00007238.pdf

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