Organization:

Can an unproductive Stone pine stand be recovered?

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Objective: Evaluate the effect of pruning on the vegetative response of trees and pinecone production.

INTRODUCTION

The production of pine nuts is currently decreasing (as production remains on natural stands), causing an increase of the product price in the market, and thereby facilitating the inflow of foreign pine nuts species as alternatives for the Mediterranean pine nut. The decline in production is attributed to the incidence of various biotic and abiotic factors, but also can be attributed to the aging and the poor management of natural stands. The present study is focused on an unproductive seedling orchard of Stone pine of 5.5 ha located in Sils, Girona (Northeastern Spain). The orchard was planted in 1995-1996 and in 2022 it was thinned resulting in a current density of 400-425 tree/ha. In 2015, the owner carried out a pruning intervention for pine nut production recovery (figure 1).

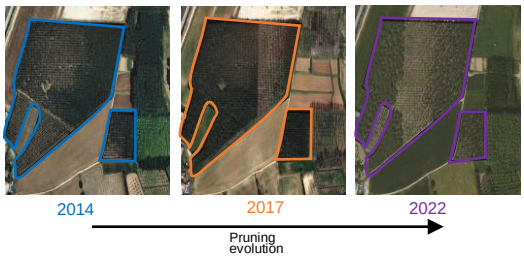

Figure 1. Pictures of the plantation pruning evolution.

Figure 2. Pictures of the differentiated zones of the plantation based on the pruning applied.

MATERIAL & METHODS

This study started on 2022. To evaluate the effect of pruning in the vegetative response and pinecone production, three zones were plotted in the stand considering the pruning management applied: a zone without pruning (**NP**), a zone pruned in 2021 (**P1**) and a zone pruned between 2015 and 2019 (**P2**) (figure 2). The reproductive response was evaluated in five subplots of 20 trees within each zone (figure 3) (300 pine trees were evaluated). The effect of pruning was analyzed per tree considering the vegetative growth (figures 4 & 5) and the productive response by recording the number of conspicuous strobiles (1st year cones) in 2022 and 2023, and the 2nd year cones in 2023 (figure 6). Statistics (ANOVA) and geostatistics using the interpolation of inverse distance weighted (IDW), were applied to all vegetative and productive parameters.

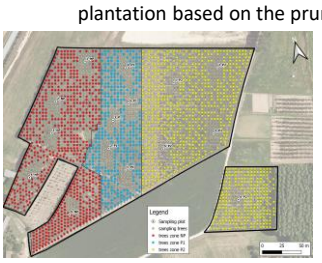

Figure 3. Map of experimental design after the thinning.

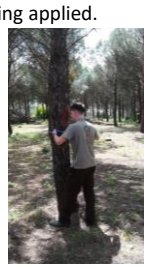

Figure 4. DBH measuring

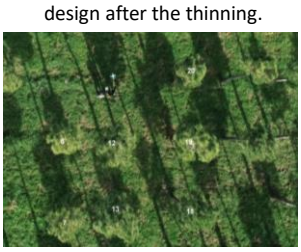

Figure 5. Aerial view of plot. Evaluation of canopy surface

Figure 6. Pinecones counting

RESULTS & DISCUSSION

Vegetative growth

Significant differences between zones in all vegetative growth parameters were observed (Table 1). Trees belonging to **P2** zone (pruned between 2005-19) showed the greatest mean and increase (Δ) on canopy surface (CS) and diameter at breast height (DBH); while trees of the NP zone (non pruned) showed the smallest increase (Δ) for all data considered. Trees from P1 zone (pruned between 2020-21) showed the smallest canopy mean, as the logical consequence of its recent pruning. However, the increment of the canopy, DBH or total height between 2022 and 2023, was higher than the observed on the **NP** zone. The presence of *Diplodia pinea* decreased in all pruned trees.

Table 1. Average and increment of the vegetative growth between zones.

Zone	Mean CS (m^2)	Δ CS (m^2) 2022-23	Mean DBH (cm)	Δ DBH (cm) 2022-23	Mean H (m)	Δ H (m) 2022-23
	*	*	*	*	*	*
NP	19.3a	2.17a	26.1a	0.54a	9.3a	0.15a
P1	7.5b	2.53b	24.4b	0.63a	9.1a	0.39b
P2	23.5c	4.47c	30.6c	0.85b	12.0b	0.38b

* Significance at zone level p<0.0001

Different letters show significant differences; CS: Canopy surface; DBH: Diameter at breast height; H: Height

Pinecone production

There were significant differences between zones in terms of pinecone production (1st and 2nd year cones) (Table 2 and Figure 7). The trees of the **P1** zone produced more 1st year cones per canopy surface than **NP** and **P2** during the two years of evaluation (2022 and 2023). The improvement of lighting in the canopy in **P1**, caused an immediate effect on tree fructification. However, there was a high lost of 2nd year cones, as only the 8% of strobili became as 2nd year cone, decreasing from 1.2 cones/m^2 to 0.1 cones/m^2, respectively (Table 2). However, in the **P2** zone the decrease of the 1st year cone to the 2nd year cone per canopy surface was of 30%. These results suggest that higher canopy surface in **P2,** which was nearly the doble than in **P1,** could be the reason of the higher survival rate from strobili to 2nd year cone in the trees. Finally, the pinecone production of the **NP** zone was very low, as there were barely cones of any age.

Table 2. Pinecone production of 1st and 2nd year cones per canopy surface.

Zone	2022 mean 1st year cone (cone/m^2 canopy)	2023 mean 2nd year cone (cone/m^2 canopy)	2023 mean 1st year cone (cone/m^2 canopy)
	*	*	*
NP	0.1a	0.02a	0.03a
P1	1.2b	0.1b	0.68b
P2	0.9b	0.27c	0.49c

* Significance at zone level p<0.0001

Different letters show significant differences

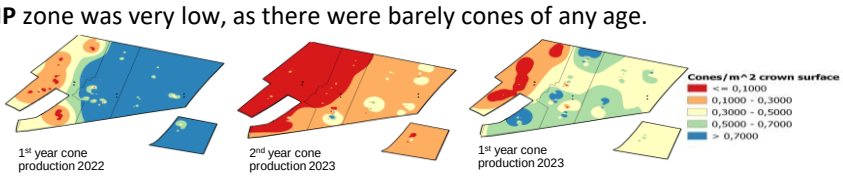

Figure 7. IDW geostatistical analysis of the pinecone production in 2022 and 2023.

CONCLUSIONS

Pruning applied on adult stone pines showed a positive effect on tree growth, pruned trees showed a higher increment in growth parameters than non pruned ones.

The presence of strobili and 2nd year cones was almost nil without pruning on 27 years old pines.

Trees reacted immediately to increased canopy illumination by producing a greater number of strobili.

Special attention should be paid when pruning too severely, canopy recovery requires some time as tree needs an active photosynthetic surface to sustain its production over time.