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## Natural regeneration of *Pinus pinea* L. in Tunisia as influenced by canopy cover, litter biomass and understory vegetation

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### Key words

Regeneration, litter, pine, light, vegetation competition

### Introduction

Due to its ecological, aesthetic and economic values and its ability to withstand low intensity fires, the stone pine (*Pinus pinea* L.) is one of the most valuable species used in Tunisia for reforestation (Sghaier et al. 2006). However, little is known about natural regeneration possibility and particularly how abiotic factors such as soil fertility, temperature, humidity and light and biotic factors such as litter, understory vegetation and herbivory affect the process. This species is shade-intolerant and hence needs light to correctly regenerate but to an extent that should be specified. The understory vegetation and the litter quantity, both also related to light availability, are also known to influence stone pine regeneration. A better understanding of these processes would consequently help forest managers to secure the stand regeneration. The objective of the study was to relate the occurrence of stone pine seedlings in relation to stand structure including canopy cover, litter and understory vegetation in two forests of North Tunisia.

### Materials and methods

The two forests, Mekna and Ouchtata, located on coastal dunes of Nefza-Tabarka, have been intensively afforested with stone pine in some parts for about 50 years. The climate is mediterranean. The soil has mostly a sandy texture. The stone pine is the only overstory species, whereas the most commonly occurring shrub species were *Juniperus oxycedrus* ssp., *Juniperus phoenicea*, *Quercus coccifera* and *Pistacia lentiscus*. There was also an herbaceous layer consisting of *Bellis annua*, *Briza maxima*, *Geranium Robertianum* and *Silene colora*. Thirty-seven rectangular (25 × 20 m) sample-plots were randomly selected. In each plot, the age, height, DBH and mean crown diameter (CD) were measured on five sample-trees, one near the centre and the others closest to the four corners of the plot. The total number of pine in each plot was also counted ( $N_t$ ). Overstory canopy cover (C, %) was then calculated by:

$$C (\%) = PCA.N_t.100/500$$

Where PCA is the projected crown area derived from ( $\pi CD^2/4$ ). The biomass of the different species of the understory and the needle litter was recorded in 8 square subplots (0.25m<sup>2</sup>). The number and age of stone pine seedlings were also determined in each plot.

### Results

A bell-shaped unimodal curve was recorded for the number of stone pine seedlings ( $N_s$ ) according to overstory canopy cover (C) with a peak for the class 43, 5 – 58% ( $p < 0, 0001$ , fig.1). Stand age had also a significant positive effect on  $N_s$  ( $p < 0.003$ , fig. 2). C and stand age was often linked with a decrease of C for young stand, explaining the decrease of  $N_s$  for the first cover class (29 – 43.5%, fig. 1).

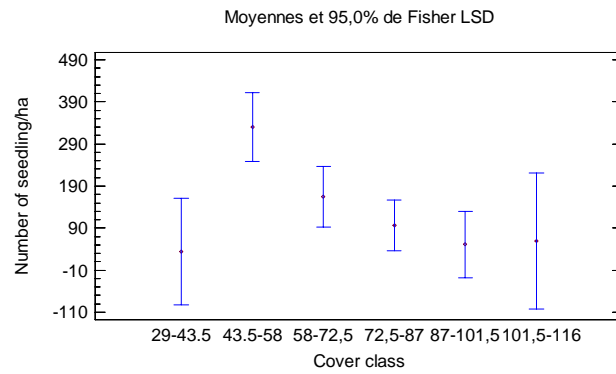


Fig.1. Number of *P.pinea* seedlings according to overstory cover (divided by classes of 14,5%) into forests of the coastal dunes of Nefza-Tabarka, Tunisia

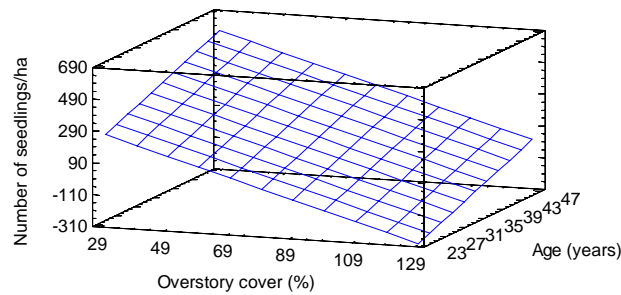


Fig.2. Number of *P.pinea* seedlings relative to overstory cover and stand age in two forests of the coastal dunes of Nefza-Tabarka, Tunisia.

The litter quantity significantly decreased  $N_s$  ( $N_s = (550 - 8.7 * \sqrt{\text{Litter}})^2$ ;  $R^2 = 38\%$ ;  $p < 0.0001$ ; fig. 3).

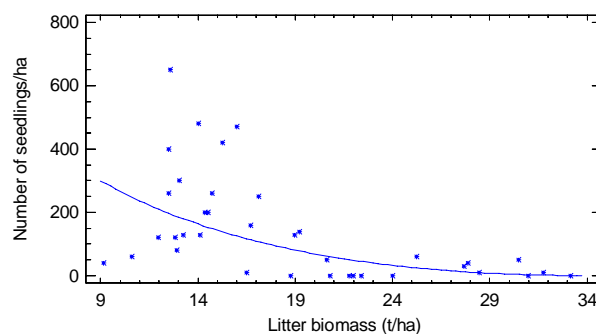


Fig.3. Relation between biomass of litter ( $t/ha^{-1}$ ) and relative number of *P.pinea* seedlings in two forests of the coastal dunes of Nefza-Tabarka, Tunisia.

The biomass of the understory vegetation (shrubs, grasses and forbs) had globally no significant effect on  $N_s$  ( $R^2 = 7.53\%$ ), whereas the p-values tended to show that grasses had the most negative impact (0.36, 0.2 and 0.63, for shrubs, grass and forbs, respectively).

Stone pine seedling age varied with C, with seedlings older than 2-year-old were recorded mostly for  $C < 72.5\%$  (Fig. 4).

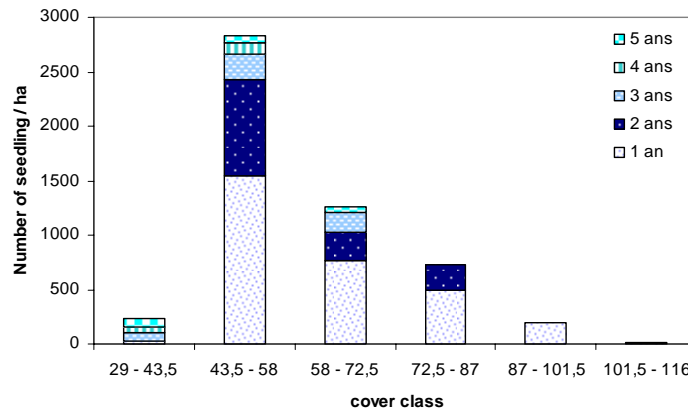


Fig.4. Distribution of the number and age of *P.pinea* seedlings according to the cover class in two forests of the coastal dunes of Nefza-Tabarka, Tunisia.

### Discussion:

Stone pine seedling number and age were negatively correlated with overstory canopy cover. Stand age favored  $N_s$ , probably through an increase of cone and seed production with tree age. A decrease of  $N_s$  for the first class of cover is linked to the intrinsic structure of data, i.e. the stands with the lowest cover were also the youngest, and consequently with a low seed production.

Litter quantity had a negative effect on seedling recruitment and establishment, in accordance with the results of other studies (Bosy and Reader 1995; Facelli and Facelli 1993; Fowler 1988). Thus, litter may delay or abort seedling emergence either by preventing contact between seminal root and mineral soil, through mechanical restriction to hypocotyl elongation and emergence of cotyledons (Cacia and Ballaré 1998), or by chemical effects by dissolved litter substances (allelopathic effect) (Bosy and Reader, 1995). The understory vegetation did not seem to have a marked effect.

As a consequence, the effect of overstory canopy cover on seedling number and age would imply a light effect, i.e. an increase of them with light, but also a litter effect, which quantity increases with canopy cover. Both factors are difficult to separate and further controlled experiments are needed to specify their respective influence.

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