Synchronization and Fertility Variation Among *Pinus nigra* Arn. Clones in a Clonal Seed Orchard

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Clonal seed orchards are the main source of forest reproductive material for the most economically important conifer species. The establishment of seed orchards aims mainly towards the production of seed crops of higher genetic value compared to those obtained from seed stands.

The flowering synchronization among clones in a clonal seed orchard has been proved to be a crucial factor for the genetic composition of the seed crop, as it affects the exchange of genes among clones. Lack of synchronization among female flower receptivity and pollen shedding can violate the basic assumption for an idealized seed orchard, which is the panmictic equilibrium (El-Kassaby and Askew, 1991; Matziris, 1994; Kang and Lindgren, 1999; Kang and Mullin, 2006). The above knowledge is fundamental for the effective management of a seed orchard.

Aims of the present contribution were to determine the clonal variation in the development of different phenological stages of female and male flowers in a *Pinus nigra* Arn. clonal seed orchard; to investigate the synchronization among female receptivity and pollen shedding; to record the variation of female and male strobili number among clones; and to evaluate the response of clones to the contrasting environmental conditions recorded among the two years of study.

The study was carried out in a black pine clonal seed orchard that comprises sixty clones originating from Northern Greece. The study was carried out in two successive years with contrasting environmental conditions (one year with normal temperature and precipitation conditions, and one dry year with exceptionally high temperatures). The different phonological stages (scale 1-5 for male and scale 1-4 for female strobili) were recorded every second day in eight male and eight female strobili for each one of the two ramets per clone that were included in the study. Fertility was assessed during the second year of the study, by counting the total number of female and male strobili per ramet and clone.

Figure 1. Black pine clonal seed orchard (Clonal male fertility variation).

Figure 2. Receptive female strobili (phenological stage 3).

The data were analyzed separately for each individual year and combined for both years, following a mixed linear model analysis (Proc Mixed, Proc Varcomp; Sas, 1996).

From the results obtained it was shown that significant differences in male and female fertility exist among the black pine clones. Also, significant variation among clones for the male strobili dimensions was found.

It was also revealed that high genetic variation exists among clones for both the female and male flowering developmental phases. The genetic component of both male and female flowering earliness is very strong in all cases.

The year effect was statistically significant in all cases. No significant clone by year interaction was detected for the female onset, termination and duration of flowering for the stages recorded, while a statistically significant interaction was found for the pollen shedding duration.

The high heritability values found indicate that selection for flowering synchronization could be effective and result in rapid genetic gains.

The assumptions for an ideal seed orchard, as far as synchronization and panmictic equilibrium are concerned, were not met. Especially during the dry and exceptionally hot year, a well expressed asynchrony among the black pine clones was recorded, with apparent consequences on the genetic composition of the seed crop. The above finding could indicate the effect of the predicted climate change (with prolonged periods of drought and high temperature in the Mediterranean region) on the phenology of flowering and the genetic composition of the seed crop obtained from black pine seed orchards.

Literature cited

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