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Effects of clonal selection on biomass production and quality in *Robinia pseudoacacia* var. *monophylla* Carr.

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ABSTRACT

In this paper, the results of the effects of clonal selection on biomass production and quality in monophylla black locust (*Robinia pseudoacacia* var. *monophylla* Carr.) were studied. The genetic material included seedlings of open pollinated families, ramets of selected clones within them and seedlings of common black locust (*Robinia pseudoacacia* L.) as a control. Both seedlings and ramets were planted in the field in April 1994. At the end of the first and the subsequent growing seasons (1994–2002) all of them were cut at 20 cm aboveground. Measurements were done at the end of October–beginning of November and included height and oven-dry weight of saplings, stem number, leaf/stem ratio of oven-dry weight and length of the longest thorn. It was found that height and oven-dry weight were increased in the first three years but they declined thereafter both in clones and families. Overall, however, clones were superior to families. Stem number was increased with age more in families than in clones. Leaf/stem ratio of oven-dry weight declined with time but clones were superior to families. Thorn length, finally, increased over the years but clones had significantly lower values than families. The results showed that the most productive clones were also better in quality characteristics (leaf/stem ratio of oven-dry weight and thorn length) than most families and the control. It is concluded that clonal selection can result in significant increase of biomass quantity and improvement of its quality.

1. Introduction

Black locust (*Robinia pseudoacacia* L.) is a fast-growing and nitrogen-fixing tree legume, highly productive in terms of biomass, drought tolerant and well adapted to a large range of soil conditions (Keresztesi, 1988; Hanover, 1990). For these reasons, it is a potential biomass crop species for energy and forage production (Barrett et al., 1990; Bongarten et al., 1992). For this latter use several studies have been carried out in the last few years suggesting the superiority of black locust in biomass production compared with other woody fodder species as well as its high nutritive value for livestock (Papanastasis et al., 1997, 1999; Burner et al., 2005). An undesirable trait of black locust is the presence of strong thorns which arm the juvenile stems and pose a hazard to humans trying to tend and harvest the tree, although grazing animals seem not to have any problems (Roder, 1992; Bongarten et al., 1992; Dini, 1993).

Despite the high growth potential of black locust, a number of researchers have tried to improve its biomass production and quality through several management interventions. Bongarten et al. (1992), for example, employed irrigation and fertilization in a juvenile plantation of black locust; both treatments resulted in significant increases of biomass production, particularly in the first year, but these differences became insignificant by the third year. Papanastasis et al. (1998), on the other hand, found that repeated annual cutting of black locust for eight consecutive years resulted in significant reduction of both height and total biomass compared to the uncut plants but increased its grazable proportion (leaves and twigs up to 2 mm diameter), especially after the fourth year when this proportion was substantially reduced in the uncut plants. Also, pollarding seems to affect biomass production and quality. Burner et al. (2005) found that black locust yielded more foliar biomass when pollarded at 50 or 100 cm and fertilized with P than at 5 cm with or without P fertilization. Annual cutting preferably at 40 cm at the end of August is also recommended by Platis et al. (2004) for ensuring increased production of grazable material (leaves, fruits and twigs up to 2 mm diameter). Finally, biomass production per unit area is affected not only from the height of pollarding but also by spacing (Unruh Snyder et al., 2004).

Although management of black locust plantations can significantly improve their biomass production and quality, this increase is not unlimited. In contrast, better and more impressive

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results can be obtained if genetic improvement of the species is undertaken. Bongarten et al. (1992), for example, have found that family differences were large and uninfluenced by management such as irrigation and nitrogen fertilization and biomass productivity was increased by more than 50% from family selection alone. Their experiment however lasted only for three years and it is not known whether family differences would remain for a longer period of time.

Monophylla black locust (*Robinia pseudoacacia* var. *monophylla* Carr. or *unifolia* Talou) (Kavvadas, 1956; Keresztesi, 1983) is a botanical variety with a few and large leaflets per compound leaf, very promising for biomass production (Dini-Papanastasi, 1997). In a progeny test of 14 open pollinated families of this variety (Dini-Papanastasi and Panetsos, 2000), it was found that the originally significant differences in growth among the families disappeared as the plantation became 3–5 years old while no significant differences for thorn length were found among them. It was also found that growth was positively correlated with increased thorn length. The question raised then was whether clonal selection within these families can result in an increase of production capacity, reduction of thorn size and improvement of leaf/stem ratio of oven-dry weight. In other words, if this selection could find the so called "correlation breakers" (Libby, 1983), i.e. the segregating individuals within families which could combine high growth potential and reduced thorn size. The objective of this paper was to compare selected clones of monophylla black locust and the open pollinated families within they have been selected in terms of biomass production and quality, so that the potential of clonal selection in this species is investigated and discussed.

2. Materials and methods

The research was carried out in the farm of the Forest Research Institute of Thessaloniki, in northern Greece (40°35′N and 22°58′E). Soils of the study area are sandy loams, derived from deposits of the tertiary period, fairly deep (1–2 m) and alkaline (pH 7.7). Long-term mean annual rainfall is 438 mm and mean minimum temperature of the coldest month 0.5 °C (January) suggesting a semi-arid Mediterranean climate with cold winters.

The plant material tested included:

Ramets of clones (88 in total), produced from rooted stem cuttings of 12 outstanding individual trees selected in November 1992 for their prominent growth in height and diameter, their very dense, rich and green foliage (in late autumn), as compared to their neighbours, and their small thorns (<15 mm). These individuals belonged to seven out of 14 open-pollinated tree families of monophylla black locust tested in a progeny test in the same farm in 1990 (Dini-Papanastasi and Panetsos, 2000); Seedlings of half-sib families produced from seeds of: (a) seven out of 14 monophylla black locust families of the progeny test, where the 12 above mentioned clones belonged (216 in total) and (b) a seed mixture, composed of 20 seeds from each one of all the 14 monophylla black locust families of the progeny test, representing the average population and symbolized as C_0 (31 in total); Seedlings of a common black locust tree (*R. pseudoacacia* L.), as a control (C) (31 in total) (Table 1).

The 14 families tested in the progeny test were produced from seeds of 14 monophylla black locust mother trees growing in the farms of two Experimental Stations, near and about 100 km NE of Thessaloniki. The mother trees were selected for their few thorns and the small number of leaflets per compound leaf. All the sampled trees were offspring of a single tree, which was growing in a plantation of black locust established for erosion control in the catchment area of a torrent near the town of Serres, north-east Greece. This particular tree was distinguished from the rest, because of its vigorous growth and the absence of thorns from its branches (Dini-Papanastasi and Panetsos, 2000).

Table 1
Monophylla and common black locust open-pollinated families and monophylla clones selected within the respective families

Families	Monophylla clones selected within the families
Monophylla black locust	
8A	A-8A(4)
	A-8A(7)
	A-8A(9)
2B	B-2B(8)
	C-2B(13)
	A-2B(15)
A	A-A(7)
	B-A(13)
7B	A-7B(6)
B	A-B(3)
3A	B-3A(7)
6A	B-6A(8)
C_0[a]	–
Common black locust (C)	–

[a] Average population: a seed mixture, composed of 20 seeds from each one of all *monophylla* black locust families.

For the production of ramets, hardwood cuttings were collected in January 1993 and planted in rooting benches in the greenhouse in order to have them rooted (Dini and Panetsos, 1994). The rooted cuttings were transplanted to plastic bags.

For the production of seedlings, seeds were collected in 1992. In April 1993, they were sown in paper pots after being soaked in hot water for 24 h to facilitate their germination and powdered with fungicide to protect them from diseases. Following their germination in a few months, they were transplanted in plastic bags, the same as the ones used for the cuttings.

The experiment was established in the field in April 1994. A completely randomized experimental design was employed (Steel and Torrie, 1980). Altogether 420 saplings were planted in 30 rows with 14 individuals each in a spacing 2.5 m × 2.5 m. Also, a row of one-year old bare rooted common black locust seedlings was established around the plantation with the same spacing to serve as a buffer zone. However, 366 saplings out of the 420 were studied in this paper (Table 1); the remaining 54 were ramets that belonged to two other clones, which were not evaluated in the progeny test. Both ramets and seedlings were cut at the end of the first and the subsequent growing seasons (1994–2002).

Measurements were carried out at the end of the growing season (end of October–beginning of November). They included:

(i) Height in cm of the tallest stem of all the saplings of the plantation (ramets and seedlings) for the years 1994–2002.
(ii) Oven-dry weight (in grams). All saplings from each clone and 20 saplings randomly taken from each family were cut at 20 cm aboveground and weighed. In the first three years (1994–1996), a representative sub-sample from each of them was taken, weighed, separated into leaves and branches and weighed so that the fresh weight is found. Subsequently, the separated leaves and branches from were transferred to the laboratory, where they were oven-dried at 65 °C for 48 h and weighed. The oven-dry weight of the sub-samples was then used to calculate the corresponding oven-dry weights of the whole saplings for stems, for leaves and by summing up the total plant weights in 1996. In the following years 1997–1999, only the total plant weights were estimated.