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Study on the competitive strategies of Black Locust (*Robinia pseudoacacia* L.) in a mesophylic wood of Northern Italy

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Abstract

The Black Locust (*Robinia pseudoacacia* L.) is a cosmopolitan and extremely adaptable plant thanks to the different strategies adopted in the interspecifical competition. In this study, beyond the strategy known as allelopathy, we focus on a rarely investigated aspect of the ecology of this tree, i.e. the phenomena of the presence of thorns on the trunk (mechanism of defense against the ungulates) in the first years of growth and their disappearance as the bark becomes thicker. It is found that the presence of thorns is limited to young branches in mature individuals and that a relationship with the age through the trunk rings can be drawn.

Keywords: *Robinia pseudoacacia,* Black Locust. competition, allelopathy, thorns, bark, interspecific strategies

Riassunto

La Robinia pseudoacacia L. risulta essere una pianta estremamente adattabile e cosmopolita grazie alle diverse strategie che adotta nella competizione interspecifica. In questo studio, partendo dalle strategie note come l'allelopatia, ci si sofferma in particolare sul ruolo che svolge nell'ecologia della Robinia il rapporto che intercorre tra la presenza di spine sul tronco (meccanismo di difesa dagli ungulati) nei primi anni, lo spessore della corteccia e la velocità di crescita, aspetti che risultano essere i primi contributi sul tema.

Parole chiave: *Robinia pseudoacacia,* competizione, allelopatia, spine, corteccia, strategie interspecifiche

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Introduction

Black Locust (*Robinia pseudoacacia* L.) is a plant of *Fabaceae* family, native of the North America (southern Appalachian ridge) and widely naturalized in Europe and in other continents. With a 60/70-year-old longevity, exhibits an arboreal (until 25-30 m) or shrubby behaviour with a strong agamic reproductive activity (Cierjacks et al., 1992). In the juvenile stage, it presents a smooth bark with robust couples of thorns which tend to disappear as the plant reaches its maturity. Black Locust doesn't succeed propagating in the mature and undisturbed woods, but it does well in those where some cuts with the formation of small clearings are performed. Once introduced in new and degraded environments, it behaves as pioneer and invasive, having a high speed of growth and competing therefore successfully with the other native species of slower growth (Benesperi et al., 2012). Black Locust prefers loose and well drained grounds even poor of nutrients, succeeding in colonizing degraded and arid environments, and its extreme ability of adaptation brings it to colonize environments spanning from the seashore to 1500 meters of altitude in Southern Italy (Pignatti et al., 2018). Nearly pure woods of black locust is found to cause a decrease of biodiversity, preventing the normal expansion of other arboreal and shrubby plants. As well as other *Fabaceae,* this species is able of to fix molecular nitrogen through the gram-negative bacteria (rhizobia) present in its radical nodules (Von Holle et al., 2006; Pupillo & Marconi, 2019). The success of Black Locust in the competition with the other arboreal species not only resides in the vigorous growth but also in the different strategies adopted, such as the production of allelopathic substances, the presence of thorns (a mechanism of defense against the action of bark-peeling of ungulates and hares) and the production of pods full of seeds that thanks to their lightness can be easily scattered by the wind (Martin, 2019).

In this study we investigate some aspects of the different strategies of competition adopted by Black Locust, focusing our attention on early thorn production. It is known that the allelopathy plays a fundamental role in the defense mechanisms of a wide number of plants against bugs, vertebrates, bacteria and mushrooms and black locust doesn't make an exception: it produces allelochemicals to compete with other plants, operating an effective chemical war in the ground, reducing, or preventing seed germination of other species (Mauseth et al., 2016). Different studies have underlined that the production of chemical allelopathic substances affecting the surrounding vegetation has allowed Black Locust an extraordinary ability of adaptation (Nasir et al., 2005; Madina - Villar et al., 2017). The concentration of allelopathic compounds inside black locust tree is correlated to its age: the growth size has a meaningful effect on the production of phenols and the young plants have been found to produce more of these allelochemical substances in comparison to the adult ones (Carter et al., 2017). The larger production of allelochemicals in the young plants of black locust could depend on the fact that during the colonization process of a new environment, the initial competition with other arboreal essences is of fundamental importance. Carter et al. (2017) reported that Black Locust in environments different from its native drives a large part of Net Primary Production (NPP) to the height competition with other plants, whereas in the regions of origin it employs more energy to produce allelopathic substances released in the ground, as a strategy of competitive advantage. From previous searches it turns out that the growth of the aereal part of the plant is particularly rapid during the good season if compared with that of neighbouring trees (Grossoni, 2018).

In this study we have investigated a poor known aspect of the ecology of Black locust, i.e. the relationship among the presence of thorns on the trunk, the thickness of the bark and the growth-rate. We believe that the preservation of a tender bark for a certain period is a strategy of the plant to grow fast and therefore to have more chances to conquest vital spaces.

Materials and Methods

The present investigation was carried out in the Valsugana valley, in a foothill area enclosed in the communes of Madrano and Canzolino at an altitude of around 580 s.l.m: here different areas of naturalistic interest (biotopes) are found with some little ponds and wooded areas (mixed wood), intercalated by small fields and terraced vineyards with southern exposition. For our search we selected a mesophylic wood composed especially by pines (even secular) with widespread presence of hornbeams, chestnut trees, manna-ashes, wild cherries and black locusts, representing a meaningful laboratory of investigation. Random cuts of the wood are usually carried out.

During our investigations we examined 40 samples of locust trees recording the ring sections of the trunk ascribable to different ages, as well as the thickness of the bark and the number of thorns and if these resulted bedewed by the sap or they were dried, since many adult Black locust preserve traces of thorns that do not develop any defensive action anymore.

Results and Discussion

The results, summarized in the plot of figure 1, refer to 1–10-year-old Black Locust samples. We observed that Black Locust begins to thicken gradually the bark starting from the fifth-sixth year of age, but for several years it possess a rather tender bark that certainly doesn't shelter it from the possible bark-peeling by ungulates and hares: to obviate this risk it produces hard thorns that are going to gradually disappear around the tenth year, when the bark of the trunk has become sufficiently wrinkled. The data show the existence of a relationship

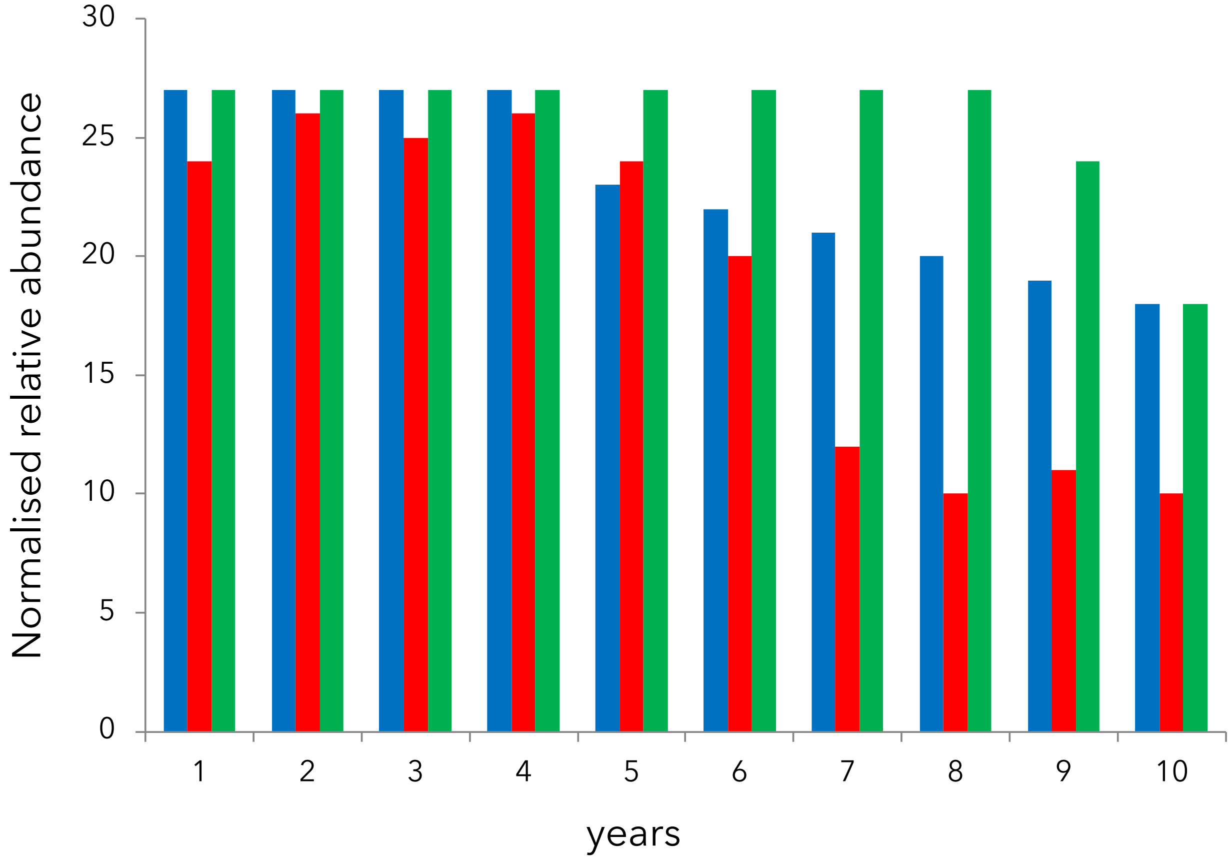

Figure 1: Qualitative representation of the main features of the examined trunks of Black Locust. The data refer to an average sampling of 1-10 years old plants. Maintenance of tender bark (blue); trunk diameter (red); presence of thorns (grey).

between the presence of thorns on the trunk, the width of the bark and the rate of growth of the plant. These facts are confirmed by the examination of the tree rings, showing a remarkable growth rate in the first years followed by a decline as the tree becomes older (Fig. 2A); moreover, as can see in figure 2B, bark appears tender and prickly during the early years. Indeed, not having need to produce a thicker bark, but protecting from herbivores with the aid of thorns, Black Locust can use the "saved" energy to grow fast, therefore competing successfully with the neighbouring trees. Once that it has won the competition, also thanks to the allelochemicals produced and released in the ground, it can thicken the bark and lose the thorns on the main stem, while the branches, remaining vulnerable, continue to produce thorns.

The competitive success of Black Locust is due to intrinsic characteristics, as extreme adaptability to the soil and climatic conditions, very effective seed-dispersal strategies, and also to the production of allelochemical substances released in the ground, that control the germination of other plants (Martin, 2019).

In this respect, driving the energies to the growth in the first years, delaying the thickening of the bark, can also play a pivotal role in competitive success of this species. Young stems of Black Locust display a wide array of thorns, a structural modification that requires low energetic investment on the short run. Other American trees, for example

Figure 2: A ,Transversal section of a mature trunk of Black Locust. Noteworthy is the width of the central rings with respect to the peripheral ones, giving evidence of the vigorous growth in the first years of life. **B**, Progressive thickening of the bark in juvenile samples of Black Locust .

Gleditsia tricanthos (Fabaceae), and *Chorisia speciosa* (Malvaceae) produce thorns on the trunk (and the branches) to defend themselves from the herbivorous vertebrates, but, unlike Black Locust, they preserve them in adult age. Physical defences are definitive, and their chemical constituents can not be recycled. Thus, in the long run, the energy cost due to their construction is not negligible (Bagella et al., 2019). This could explain why Black Locust tends to produce thorns on the trunk only during the first years of life.

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