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Black locust and its role in Europe and Asia

Diploma Thesis

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Declaration

I hereby certify that I have elaborated my thesis independently, only with the expert guidance of my supervisor doc. Ing. Ivan Kuneš, Ph.D. I further declare that all data and information I have used in my thesis are stated in the references.

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Mumin Umut Suslu

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I would like to express my sincere gratitude to my supervisor doc. Ing. Ivan Kuneš, Ph.D. for providing their invaluable guidance, comments and suggestions throughout the course of the thesis.

I dedicate this work to my supervisor doc. Ing. Ivan Kuneš, Ph.D., my family and my girlfriend. This thesis would not be possible without the help of these people.

I am thankful for my family and my girlfriend for their support and courage throughout the years and during the realisation of this work.

Abstract

This study aims to have a general overview of the importance of *Robinia pseudoacacia* L. also well known as Black locust and its importance for the Europe and Asia. Black locust is an invasive alien species that originates in the Northern part of the United States. Through years, it has invaded many European and Asian countries since the beginning of the 17th century. It has been concluded that Jean and Vespasian Robin play an important role of introduction to the Europe. Despite of its invasion, it became a part of many European and some Asian countries. It is well known with its soil improving properties, ability of fast growing and domination on disturbed sites as a pioneer tree species. Fast growing ability makes the black locust an important tree species in terms of wood production with short rotation coppicing. Honey production from black locust is the second economical important trait and it is increasing, especially in Hungary. It has gained a place all over the world with its use in different purposes in other countries. Reforestation applications on disturbed sites in Greece, recognized as a biomonitoring tool in Turkey for air pollution, economic purposes are considered more important in Germany, soil improvements on poor sites recognized in China, it has gained an important place in most Central European countries, especially Hungary and Romania. Besides of positive economic traits, eutrophication and acidification on soil, competitive and extreme invasive characteristics are considered as important negative environmental impacts. Conflicts are between natural conversation, forestry, public and beekeepers became inevitable. However, future of black locust can be hopeful if invasiveness of black locust taken under control with appropriate management methods.

Keywords: *Robinia pseudoacacia*; invasiveness; silviculture; eradication; seed management; seed bank, nitrogen fixation, pioneer,

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1. INTRODCUTION

1.1. Introduction of *Robinia pseduoacacia* L. to the world

Robinia Pseudoacacia L. is a member of the *Fabaceae* family, sometimes named as a yellow locust but most commonly known as a black locust (Huntley, 1990; Vítková et al., 2015). Black locust originates in the eastern part of the United States of America. In more particular terms, it is native to the Appalachian regions in the North America (Deneau, 2013; Huntley, 1990; Carl et al., 2019; Boring and Swank, 1984; Vítková et al., 2015; Sádlo et al., 2017; Rédei et al., 2011). In more particular terms, its native range is centered in the Appalachian Mountains and eastern part extends from central Pennsylvania and southern Ohio, Alabama, northern Georgia and South Carolina. The western part includes Ozark Plateau of southern Missouri, northern Arkansas and eastern Oklahoma. It is widely planted and become a native in other parts of the United States and in southern Canada, Europe and Asia (Huntley, 1990).

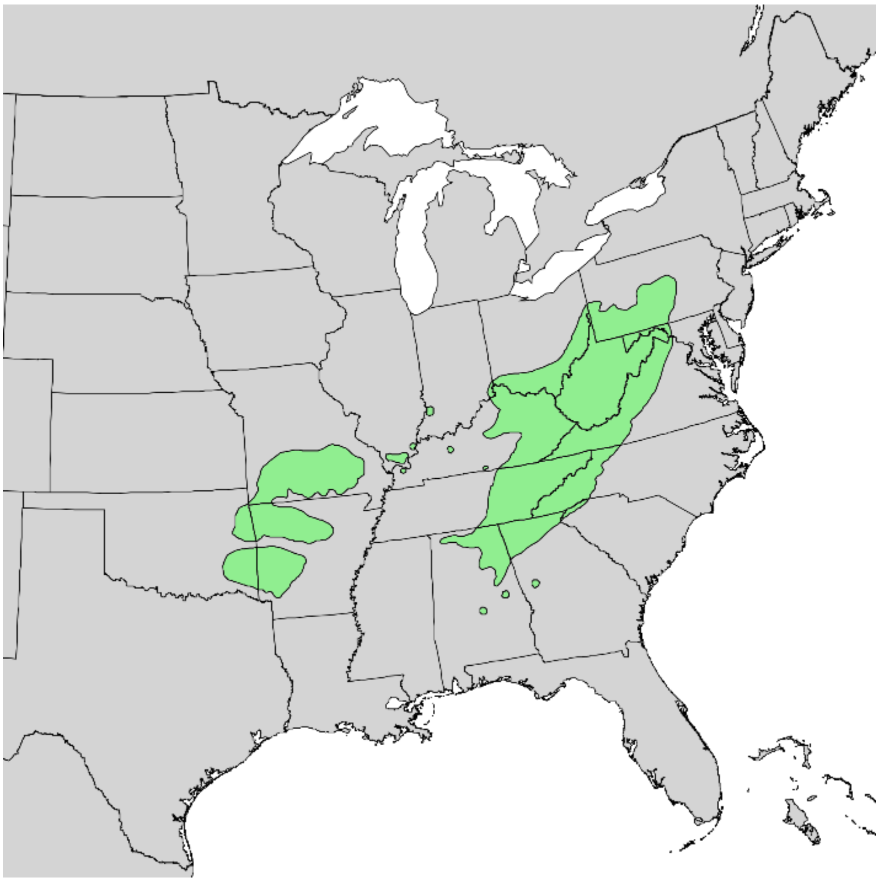

Figure 1. Native range of black locust (Figure source: Wikipedia, 2020)

Black locust is one of the most widely planted North-American tree species throughout the world in these days (Deneau, 2013; Vítková et al., 2015; Keresztesi, 1988; Rédei et al., 2011). It was introduced to many continents and parts of world such as Europe, Asia, Africa, Australia and New Zealand (Vítková et al., 2015; Deneau, 2013).

The introduction of black locust probably started at the beginning of the 17th century. Black locust was the first North American tree species imported to Europe (Nicolescu et al., 2018; Carl et al., 2019; Deneau, 2013; Rédei et al., 2011) and it has also special place in forestry history as being one of the first American trees introduced to Europe in the early 16–17th century (Keresztesi 1980; Peabody 1982; Deneau 2013). The introduction of black locust continued to Australia, New Zealand and other parts of North America (Keresztesi 1980, Deneau 2013). Currently, black locust broadly planted in some of the European countries, Korea, China and other Asian countries (Boring and Swank, 1984).

According to some authors (e.g. Keresztesi, 1988, Nicolescu et al., 2018, 2020), black locust was brought to France in 1601 by Jean Robin, the gardener of French kings. Even though the original tree that Jean Robin allegedly planted in Paris did not survive, one of its offsprings should still stand in Paris (Demené and Merzeau 2007 in Nicolescu et al., 2018). On the other hand, it is much more probable that black locust was introduced to Europe by the British, Spanish and Portuguese in more independent ways (Peabody, 1982; Kuneš et al., 2019). However, black locust was named as *Acacia Americana Robini* by Cornutus in 1635 in honor of Jean Robin. In Central Europe, Germany was probably the first country where introduction of black locust occurred in Berlin around 1672. Quickly, the species became very popular in southern part of Germany. In Hungary and then the Czech Republic (Kingdom of Bohemia) black locust is first reported by 1710 (Vítková et al., 2017). It became very popular and has been broadly planted in the Central Europe and elsewhere in the Old Continent between the 18th and 19th centuries.

1.2. Distribution in European countries

Currently, black is a widespread taxon across Europe and occurring in many European countries, especially in Germany, France, Ukraine, Italy, Hungary, Western Poland, Czech Republic, Southern Slovakia, Southern Norway and as well as Eastern Asia (Sitzia et al., 2016; Nicolescu et al., 2018; Carl et al., 2019). Through many different propagation methods, introduction and spread of black locust has been continued in Europe as well as in other continents (Peabody 1982; Kuneš et al., 2019). Due to this rapid spread, it was survived and planted to Hungary in 1701, approximately in the 1710s it has been planted to Slovakia and England (Keresztesi 1980, Peabody 1982, Deneau 2013).

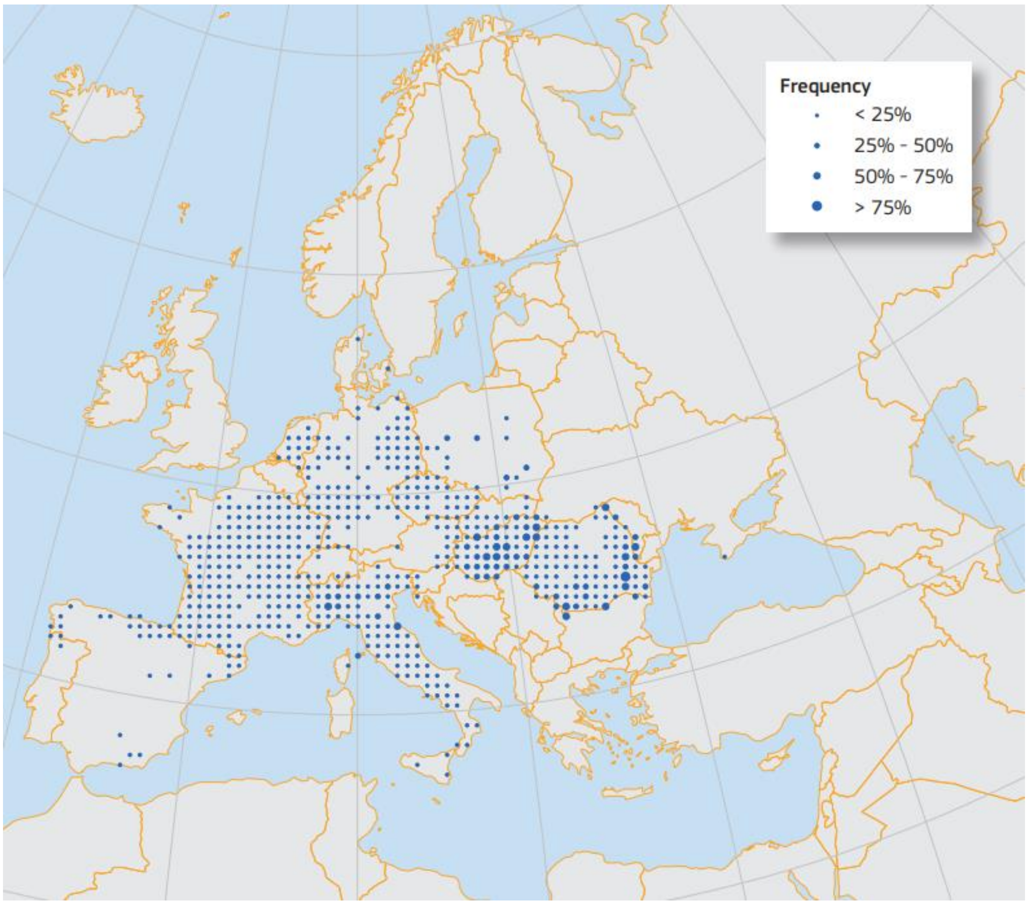

Figure 2: Distribution of Robinia pseudoacacia L. in Europe (Sitzia T. et al., 2016).

In Europe, black locust is one of the most used nonnative tree species and approximately it covers the area of more than 2 million ha (Brus, 2006 in Nicolescu et al., 2018). Hungary with 465,000 ha is one of the most occupied, Ukraine with 423,000 ha, Italy 377,000 ha, Romania 250,000 ha, France 191,000 ha, Serbia and Bulgaria currently covered by black locust in Europe (Vítková et al., 2017; Nicolescu et al., 2018; Kuneš et al., 2019). Black locust stands cover 14,000 ha of forest area in the Czech Republic (Vítková et al., 2017).

Figure 3: Distribution of Robinia Pseudoacacia L. in Central European countries (Vítková et al., 2017).

1.2.1. Distribution in Hungary

Distribution of black locust in Hungary is referred among other European countries due to the highest recorded area of *Robinia* in Europe. Additionally, among other European countries, Hungary has been chosen for this subsection with as black locust provides a significant contribution to the Hungarian economy.

As for the forestry cultivation in Hungary, *Robinia pseudoacacia* L. was first used for afforestation purposes to protect the fortification of Komarom-Herkaly with area of approximately 290 ha in 1750 (Vítková et al., 2017). This afforestation was successful and black locust began to be popular for forestry purposes in the country. Its distribution increased rapidly. To document this, the area occupied by black locust stands was 37,000 ha in 1885 whereas it was more than 400,000 ha in 2009. Currently the species covers more than 20–25% of total forest area and it is the most widely planted tree species in Hungary. More than half of black locust stands are high forests and rest of them are coppice forests (Rédei et al., 2011).

Nyirseg Region in the east part, Danubetisza Interfluve in the west part, Hill-Ridges of Baranya, Somogy and Tolna in the south west part and Hill-Ridges of Vas-Zala in the west part of Hungary are the most important black locust growing regions (Rédei et al., 2011).

Figure 4. Distribution of black locust in Hungary (Rédei et al., 2011).

1.3. General description of the Robinia pseudoacaica L.

With a height of usually 12 to18 m, black locust can be considered as a medium sized tree. Depending on climatic, soil conditions and region tree can grow up to 30–35m. Tree diameter can reach 30–76 cm. It can reach the height of 30 m and more than 2 m in diameter where conditions are suitable for the tree. (Keresztesi, 1983; Huntley 1990; Kuneš et al., 2019).

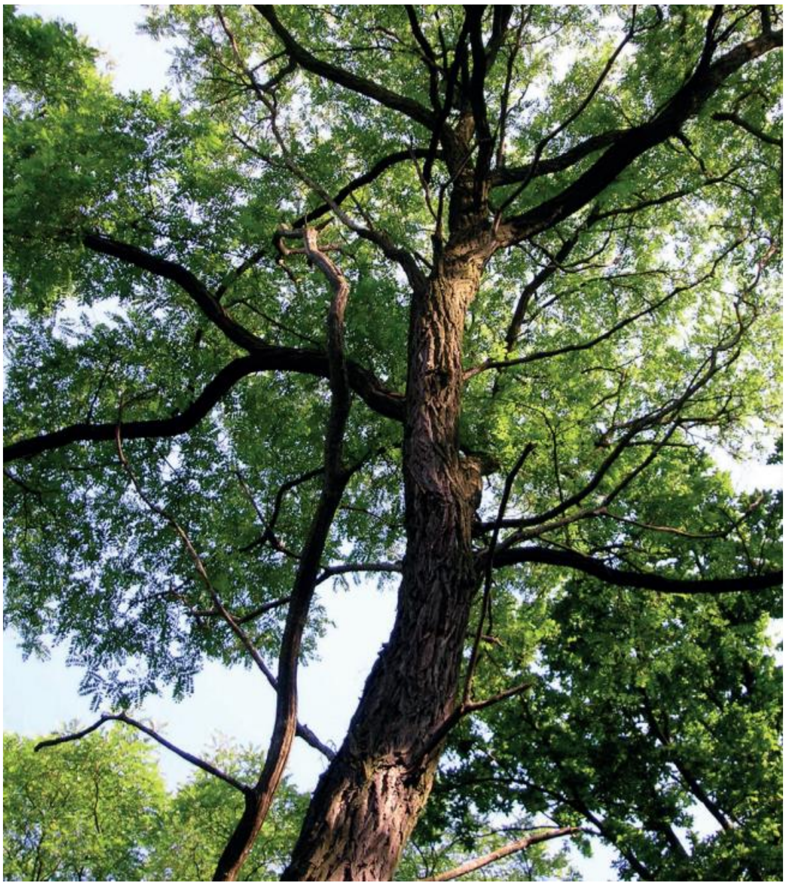

Figure 5: Black locust in Berlin, Germany (Trentanovi, 2013).

Black locust has whitish flowers that appear after leaves occur in the later spring (in central Europe usually by the turn of May and June). The flowers are primarily pollinated by bees and insects. Due to its attractive flowers, black locust is valued as a decoration tree in urban areas.

Seed production can start when the tree is about six years old. Nonetheless, the best seed production occurs when trees are 15 to 40 years old. As for sprouting, studies show that the average number of shoots per stump is approximately four and the average number of shoots per stump decreases with increasing age (Carl et al., 2019).

Figure 6. Close-up photo of black locust flower in Germany (H. Zell, 2009)

Figure 7. White flowers of Robinia pseudoacacia L. in April (Hemingway, 2003).

1.4. Varieties of Robinia pseduoacacia L.

With the highest proportion of forests area covered by black locust and the important role the species plays in economic income (honey production and timber production) for the country, Hungary has become a second home for black locust in Europe. Due to this fact, the varieties of black locust in country of Hungary are listed here. Additionally, varieties recognised in its native origin are mentioned in the forthcoming text.

In Hungary, the shipmast locust *(var. pyramidalis*) and spineless locust are preferred for the forest tree breeding. In addition to these varieties, there are 3 important varieties depending on their flowering (early, late and continuously), these varieties (*var. praecox, var. galiana and var, semperflorens*) are important for honey production. In addition in the native area of distribution, i.e. in eastern and central part of United States of America, the shape is an important parameter to distinguish the black locust forms (types). In the northern part of the species' distribution area (roughly at the elevations of 800 m), black locust type called *Pinnata* is distributed. For *Pinnata* a straight stem is typical. A tree type called *Palmata* with a crooked main part of a stem that is not visible in the crown usually occupies the medium elevations of Appalachians. Last type, called *spreading type*, is distributed at the low elevations of Appalachians. This is not considered as a suitable type for silviculture. Furthermore, there have been many varieties black locust in Hungary. Common black locust and its varieties were planted and tested at the age of 3, 5 and 7 years. Among these varieties, the variety called *Ulloi* gave better results such as higher mean annual increment of dry stem, height and diameter than common locust when both varieties reached to 7 years old. However, *Nyirsegi* shows the lowest numbers on results. This experiments shows that not all black locust varieties give same result (Rédei et al., 2011).

The reason why black locust is the most planted American tree species around globe rests in its attributes: abundant seeds, fast growing, high timber yields, honey production and wide site tolerance. Moreover, the resistance to pests and diseases (outside of its native range) and the ability to sprout make the black locust excellent for coppice. It is, however, worth mentioning that exact the same characteristics make locust an extremely competitive species with invasive potential (Keresztesi 1980, Deneau 2013).

1.5. Seed, seed coat properties, dormancy and seed pre-treatments

Reproduction of black locust occurs with seeds and root suckers. As this section is dedicated to seed and seed properties, a brief description of seed material is provided below.

Seed-bearing and production starts when the black locust reaches the age of 6 years. Seed production continues with sufficient crops of seed usually annually. Average seed production is approximately between 0.2–0.5 kg seeds per tree and 120–150 kg per ha and year. The seed quality is often very good with 96 % seed viability (Nicolescu et al., 2018). Collection of seed pods can be applied by hand or the seed can be collected from topsoil.

Figure 8: Long legume of black locust can contain 4 - 10 seeds (Marinella Zepigi, http://www.actaplantarum.org/, 2007)

As most of the *Fabaceae* family, seed coat of black locust is hard and impermeable and dormant even after many years (Kerezstesi, 1988). Due to the ability of hard and impermeable seed coat, reproduction with seeds applied successfully in Europe and Asia. The rate of germination can be improved by mechanical scarification. More specifically, pre-treatments such as acid treatment (sulphur acid applications before sowing), hot water treatment or mechanical treatment (scarification) are necessary to overcome the dormancy and increase the germination of seeds of black locust (Keresztesi 1983; Rédei et al. 2011; Nicolescu et al., 2018; Kunes at al., 2020). The dormancy is entirely due to impermeable seed coats. The directly sown and watered seeds showed germination 6 %. However, after scalding with hot water and mechanical stratification, seed germination reached 72 % and 90 %, respectively (Carl et al., 2019).

Seeds can be stored in different types of closed containers at 0–5 °C to keep seed viability at least for 10 years (Huntley, 1990).

Figure 9 – 11: Seeds of black locust in May (Simon A. Eugster, 2012), Seeds of black locust (photo: M. Baláš, 2014).

1.6. Site requirements

Different tree species require different site conditions. Black locust seedlings rapidly grow when planted on well-drained soils sites where weed competition is low. The species is sensitive to compact plastic soils. Excessively dry sites are also inconvenient for the species (Huntley, 1990) that is intolerant to shade. Initial growth can be supported by weed control.

1.6.1. Climate conditions

The climate in the native distribution area of black locust is classified as humid and super humid. However, the species can also grow well on different climate conditions such as cool temperature forests, warm and moist forests, warm and wet forests (Huntley, 1990). Black locust has a very wide climate range. In the area of its native distribution, black locust can grow where the average winter and summer temperatures are between – 4 to 7 °C and 18 to 27 °C, respectively. The optimal annual precipitation is between 1020 and 1830 mm, mean annual total snow fall is 5 to 152 cm in its native range (Huntley, 1990). In Europe, (especially in Hungary) regions with annual rainfall between 500 and 550 mm, such as lowlands and the regions where drought is frequent in summer with high temperatures around 30 °C, air humidity are between 20% and 50% in July are the most suitable regions for black locust (Nicolescu et al., 2018).

When the climatic conditions are favourable and similar for the growth of black locust outside of its native range, this supports the invasiveness of black locust. In many countries in Europe and Asia, due to similar climatic conditions black locust became invasive tree species.

Invasion of black locust usually occurs in areas with subcontinental and sub-Mediterranean climate in Europe and Western Asia. Invasion in the areas under oceanic influence is considered negligible (Vítková et al., 2017). In Central Europe, it has been naturally distributed in the elevations up to 700–1000 m, in the Alps up to 1000 m. However, there has been reported individuals black locust growing between the 1200–1640 m a.s.l. (Sitzia et al., 2016). Rainfall is between 480–800 mm per year but it is not a limiting factor for the growth of black locust. Annual temperature is between 6 and 11 °C, such areas with warm climate is favorable for the black locust.

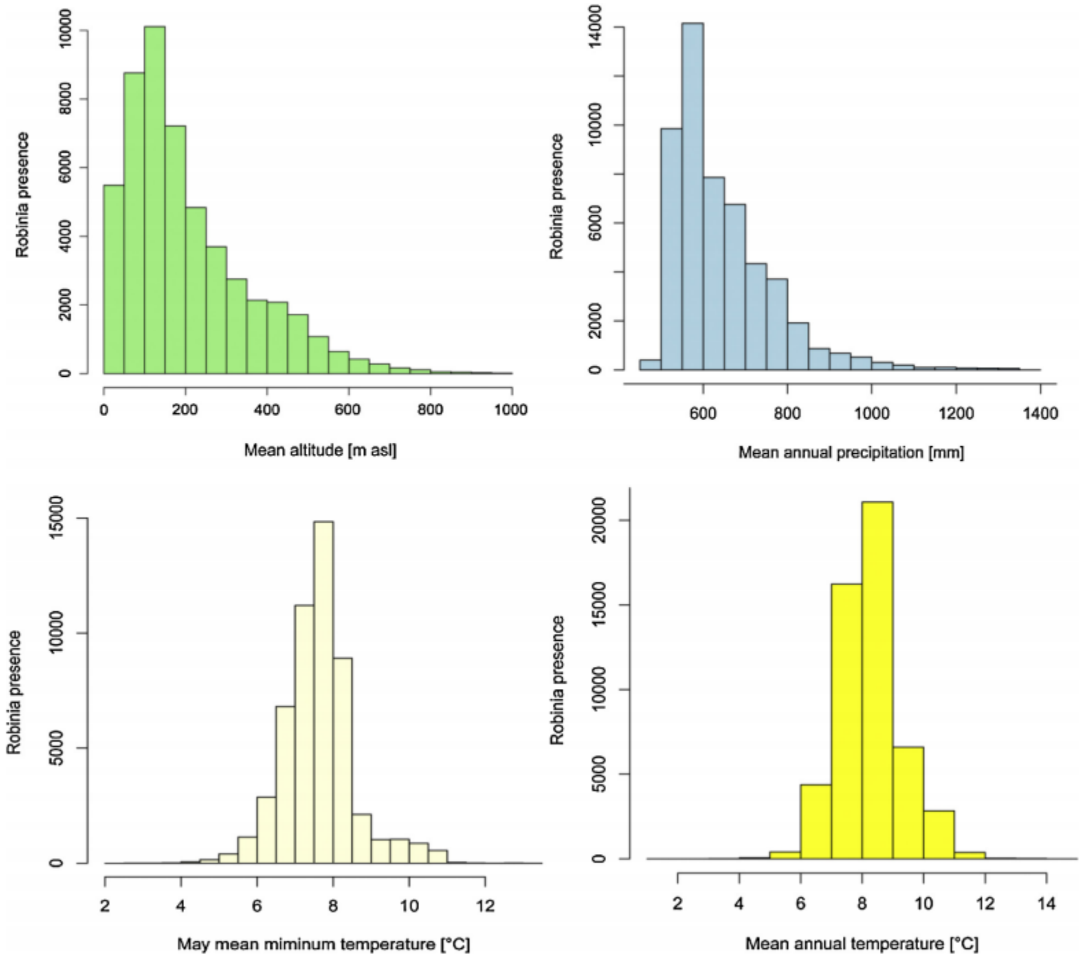

Figure 10. Proportion of Robinia pseduoacacia L. along altitudinal, rainfall and temperature gradients (Vítková et al., 2017)

1.6.2. Soil properties and soil preparation

In addition to climatic conditions, black locust can continue to grow successfully in many different soil types and conditions. Hapludults, Paleudults, Dystrochrepts, and Eutrochrepts identified as the most common soil groups and Inceptisols, Ultisols, and Alfisols are the most common soils where it can grow in its native range. Briefly, in its native range Eastern Mountains of Northern-America, black locust is able to grow rapidly on a broad range of sites. However, the best growth rate results has been observed on rich moist limestone soils (Huntley, 1990). It has been observed that it grows also best below 1040 m a.s.l where slopes are mostly humid (Huntley, 1990).

Disturbed sites are preferred by black locust. Black locust is very sensitive where the soil is poorly drained, and also dry sites are poor for the species. In silt loams, sand loams and lighter textured soils give better results when we compared with clay, silty clay loams and heavier soils. Little information observed about that black locust was the most successful species in West Virginia, however, the survival rate decreased where slope increased. Black locust failed when planted to badly eroded and clayey soils on its native range Appalachian region, plantations where it was previously agricultural crop fields due to low soil fertility (Huntley, 1990).

The initial growth rate of young trees on good sites is high; then, however, the growth rate decreases rapidly after 30 years (Huntley, 1990).

Also in Europe, the species prefers moderate and good quality soils with high nutrients in order to complete the development. When the conditions are met the black locust shows good development and a dense, quality root system using the nutrients (Keresztesi, 1988; Nicolescu et al., 2018).

It has been observed that the ground water table should be deeper than 150 cm below the soil surface, however, sufficient periodic water supply is favourable for the development of black locust in Europe (Keresztesi, 1988; Nicolescu et al., 2018). On the other hand, the soils with poor water regime, skeletal soils with high concentrations of calcium carbonates are often not convenient for optimal growth performance of black locust (Nicolescu et al., 2018). Timber quality is higher where the establishment of black locust stands has been built on sites with sufficiently moist, well-aerated, nutrient-rich and humic soils. The stands supported by poor or moderate soils can provide firewood, honey and fodder (Nicolescu et al., 2018).

Soil binding and stabilisation is a strength of black locust due to its shallow and wide-spreading root system. It can, nonetheless, also produce deep root system. This deep root system allows the locust to grow in arid lands much drier than its native range (Huntley, 1990). Additionally, black locust stands were established to stabilise sand dunes in Romania (Nicolescu et al., 2018).

1.7. Ability of black locust to fix nitrogen and its effect on soil

Nitrogen is one of the most important limiting elements for the growth and reproduction of tree and other plant species. As most of the nitrogen-fixing species, black locust plays an important ecological role on river bars, landslide debris or sand dunes. Colonisation of this kind of sites by black locust may improve the accumulation of nitrogen and organic matter (Boring and Swank, 1984). This rapid nitrogen and organic matter input are essential where the forest management methods cause the lack of a large amount of nutrients. Main source of nitrogen provided from decomposition of the leaf layer by *Rhizobium* bacteria and highest nitrogenase activity has been recorded between months of June and September.

According to study by Boring and Swank (1984), the extreme climate conditions does not affect rapid nutrient providing and as a result of observation, the 4-year-old black locust stands provided approximately 30 kg N ha^{-1} $year^{-1}$. It has been observed that a grown black locust tree can add approximately 75 kg N ha^{-1} $year^{-1}$ to the soil (Boring et al., 1981; Boring and Swank, 1984).

Black locust is classified as nitrogen-fixing tree and soil improving properties come from its nitrogen-fixing abilities (Evans et al., 2013; Brewbaker, 1990). The symbiotic nitrogen fixation rate is estimated between 23 to 300 kg hectares per year. Several studies show that, apart from adding nitrogen to soil, black locust is able to change soil reaction, organic content amount and rate of weathering (Deneau, 2013). It has an advantage over many species on nitrogen-poor soils, thanks to its extensive root system (Qiu et al., 2010; Straker et al., 2015; Nicolescu et al., 2018).

However, in terms of its effect on the soil, the situation is rather more complex. Black locust tends to enrich a site with nitrogen. Due to excess of input nitrogen, the species often causes the acidification of the soil and promotes leaching of some other important nutritional elements such as potassium and magnesium. The result is ruderalization of a site, the growth of ruderal plants on this sites. In more concrete terms, locust litter can decrease soil pH due to high soil nitrification potential and this leads to the leaching of nutrients such as calcium, magnesium, potassium (Vítková et al., 2015).

Ability of growing in broad range of different ecosystem gives an opportunity to the black locust to survive, adapt and even become more invasive species outside of its native range. Nutrient poor and dry ecosystems in Central and Western Europe became home to these invasive species (Deneau, 2013). However, nitrification and N-mineralization rates, soil nitrogen pool and available nutrient and mineral form and their increases are directly related to availability, amount and regime of moisture regime (Vítková et al., 2017).

1.8. Pioneer tree species in forest succession

Pioneer species are able to adapt to many conditions and are the most vigorous plants colonising disturbed or damaged ecosystems. The pioneers, including black locust in its native range of distribution, are the first species available on a site after disturbance in newly forming ecosystems during field succession. Therefore, black locust is usually planted on sites affected by human activities or spreads there naturally (Huntley, 1990). Human-made forest stands of black locust are described as monospecific or mixed with local and/or alien pioneer species in urban, agricultural, industrial and mining areas (Sádlo et al., 2017). Black locust can grow in a broad range and different forest types and conditions. In the area of its native distribution, black locust is dominant on early successional forest development (Boring and Swank 1984, Deneau 2013). This feature makes it an important pioneer species due to growing from stump shoots and roots and become dominant after clear cutting (Boring and Swank 1984).

In its native Appalachian region and other area of distributions such as Europe and Asia, black locust is part of the mixed mesophytic forests and it is usually common in open sites which were created by natural disturbances such as fire, cutting, floods or storms (Boring and Swank, 1984; Vítková et al., 2015). In America, as a pioneer tree species, black locust naturally dominates in the early stages of the plant succession on disturbed sites (Boring and Swank, 1984). In Europe, however, black locust forests often tend to occupy once colonised sites for a long time and outcompete local native species.

Robinia pseudoacacia L. is one of the dominant nitrogen-fixing species in secondary successional habitats as temperate regions in southern Appalachian deciduous forests (Boring, Monk and Swank, 1984). According to several scientists, *Robinia pseudoacacia* is very common and important for nitrogen cycling where fire frequency is high. With short life span of black locust trees in Appalachian regions, forest regeneration is usually dominated by root-sprouting (McGee and Hooper 1975; Boring et al., 1981).

In its secondary successional habitats, these nitrogen-fixing species are fast growing and as a result of increasing amount of nitrogen it helps to ecosystem providing nitrogen to other organism. (Boring and Swank, 1984).

Briefly, competition is not favorable for black locust and due to this fact it is classified as a shade intolerant species. It may only persist as a dominant tree (in terms of vertical structure of strand) in closed forest stands. Closed canopy and herbaceous growth prevent successful seedling establishment (Huntley, 1990). Furthermore, to be able to survive, black locust seedlings require enough light during their development process. To obtain required light black locust prefers disturbed sited such as forest fires occurred previously where it can avoid weed competition (Vítková, 2014; Kuneš, 2019).

1.9. Reproduction by seed, root suckers and stump shoots

Trees show various survival mechanisms and strategies to overcome adverse conditions and regenerate.

Black locust is able successfully to regenerate by both the reproductions strategies: generatively by seed and in a vegetative way and by root suckers and stump shoots. The initial rapid growth of seedlings, rejuvenation through root suckers and stem sprouts significantly contribute to invasiveness of locust in many countries and parts of world (Kuneš et al., 2019).

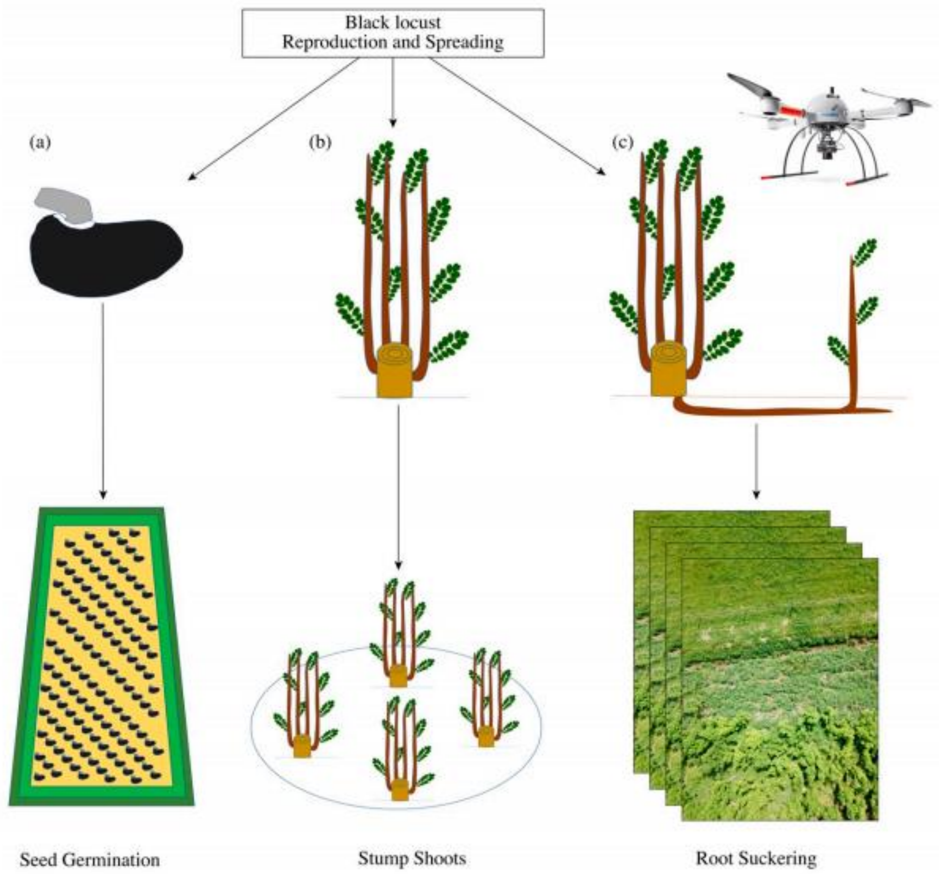

Figure 11. Reproduction and spreading methods of black locust (Carl et al., 2019).

As some broad-leaved trees, black locust shows the ability to reproduce by sprouting from stump or roots as a response to damage or cutting. Ability of stump shoot sprouting is a characteristic feature of the forest management method called coppicing. Since the coppicing is often preferred from economic point of view compared to generative reproduction of trees in many parts of the world, this traits makes the black locust popular for wood production. Where conditions are favorable for stump-sprouting, usually several shoots occur on each stump. Studies show that average number of shoots sprouting per a stump is approximately 4 and the average number of shoots per stump decreases with increasing age (Carl et al., 2017). That sprouts initially grow more rapidly than seedlings (Huntley, 1990). This was one of the main reasons why black locust was used for short rotation coppices in Germany. Moreover, it can grow fast and can grow even on nutrient-poor sites. Germany has increased the rate of fast-growing tree species such as black locust due to previously mentioned traits and aim to improve usage of renewable energy and effort to reduce the usage of fossil fuels since 2004 (Carl et al., 2019).

More specifically, black locust may be grown in short rotation regime, the rotation may be shorter than in case of many other tree species. Grow rate of the black locust is very rapid in its young age. On the other hand, this rapid growth rate decreases approximately after 30 years (Huntley 1990; Kuneš et al., 2019). Due to this decrease in growth pace the rotation of 20 to 40 years is suitable for timber production, depending on site quality. Additionally, the shorter rotation period is used for biomass production, such as in energy plantations in many European countries (Kuneš et al., 2020). However, after two rotation periods, it was observed that topsoil is exhausted and declined in productivity due to periodic removal of organic matters in the plantations that is often applied (Vasilopoulos et al., 2007). Vigorous growth in its young age, high wood density, the ability of coppicing, excellent wood combustibility and relatively fast drying and easy harvesting and processing make black locust an excellent choice for energy plantations. Several energy plantations have been established in Hungary for black. Besides of wood-processing area, black locust is used to provide inputs to different industries such as biotherapy, apiculture, food industries and landscaping (Niculescu et al., 2011, 2018; Straker et al., 2015).

Additionally, in term of reproduction by seed and ability of form a seed bank, black locust can recolonise and reoccupy a site easily.

1.9.1. Propagation methods for forestry purposes

There are a few vegetative propagation methods available for black locust. One of these methods is grafting. Grafting has been used and recommended for seed orchards establishment e.g. in Romania. The quality of scion, which depends on the mother tree's age, plays a significant role in this method.

Propagation from root cuttings is another vegetative method for the black locust. For practical forestry in Hungary and Romania, propagation from root cuttings was successfully proven. Both the mentioned countries have different way to practice this method. In Romania, 20–30 cm root cuttings taken from seedling and horizontally positioned to the soil. Shorter pieces of roots (root segments) are "sown" to the rills in soil in Hungary. In the beginning of black locust roots, irrigation is an important component of nursery care that influences root development. In further stages of root development (10–15 cm long plant) irrigation is reduced. Another method, called plant tissue culture, is actively growing juvenile shoots collected from adult trees in Hungary.

The shoots collected from dormant trees are not favourable for the shoot culture (Nicolescu et al., 2018).

However, the survival rate of trees on different ecosystem conditions depends on reproduction strategies. The survival of black locust in the different ecosystems around the globe improved by these reproduction strategies. Favorable conditions such as sandy soils and high light availability increase the spread of black locust. Most favorable soil types are considered as mineral-rich sandy and loamy-sandy for seeds (Carl et al., 2019).

1.9.2. Clone and propagation

Black locust has been widely used in many areas and become a popular tree species in Romania and Hungary. Due to high demands from customers and increasing industrial wood usage, quality tree production is stressed. Due to increasing industrial wood production and high demands for honey production from bee-keepers, several breeding programs have been developed by both in many countries, especially in Hungary and Romania (Nicolescu et al., 2018).

Clonal tests have been developed in Romania for the black locust populations identified as shipmast stem form, good natural pruning and high growth rate. Clonal tests took place at the Forest Research and Management Institute. In 1975, there were introduced 59 clones of the Romanian origin with good quality and wood production to seed orchards. Six qualified seed orchards with 27.5 ha have been established in Romania for wood production and honey producing (Nicolescu et al., 2018).

The offspring of selected trees are reproduced vegetatively in terms of breeding strategies. These breeding strategies have been developed and aimed in Hungary to improve quality of black locust stands. Several clones varieties and single clone varieties has been introduced to forestry of Hungary as a result of this breeding programme and strategies. There are more than 50 ha with more than 200 clones for the purpose of timber production, honey and energy production in Hungary (Nicolescu et al., 2018).

Due to the limited optimal areas for black locust silviculture, also suboptimal areas have been selected for growing black locust. The growth of black locust is highly influenced by climatic conditions such as temperature, precipitation, water supply and soil conditions. The mosaic pattern of site conditions, which rests in the variable mesoclimatic conditions, causes different growth potential for black locust. There are not large, continuous lands covered with black locust due to this different climate conditions in small distances. This influences the productivity of black locust across Hungary (Rédei et al., 2011).

Root cuttings and seed methods are two the most commonly used methods in Hungary for the propagation of black locust. For the seed production, there are two approved regions that meet the optimal requirements in Hungary (one of them is between Danube and Tisza rivers and the other in the Nyirseg region). Water and aeration in the soil are the most important requirements for black locust that it cannot grown any soils even the soils meet other requirements humus, sand and rooting depth. The reason of required well drained soils with moisture and aeration is provide an area for nitrogen fixing Rhizobium bacteria that they can evolve and improve the amount of nitrogen in the soil (Rédei et al., 2011).

Additionally, monospecific even-aged forest are more suitable for planting and growing of black stands. However, black locust can be grows well in mixed production stands with white poplar (*Populus alba*) and black pines (*Pinus nigra*) in European countries (Rédei et al., 2006, 2015, 2017; Nicolescu et al. 2018).

1.9.3. Role of black locust as energy plantations

Plantations of trees for fuelwood or energy biomass are called energy plantations. With the increasing demand for use of woody biomass, the proportion of such plantations tend to increase in the European and Asian countries. Moreover, there has been increase observed for the land use of both forest and agricultural areas for the dendromass production in Central European countries such as Hungary, Poland, Germany, Slovakia and Austria. Nitrogen fixation and high drought tolerance abilities predestine black locust for site revitalization and dendromass production on post-mining areas with degraded "sterile" soils. One of the most important advantages is large dendromass yield within a short period of time about 3–5 years. Additionally, irregular coppice stands when it is compared to optimised plantations have been considered as disadvantages of such forests (Rédei et al., 2008).

1.10. Different management approaches for black locust

Black locust, invaded many European countries and became a common tree species in landscape. The species could have positive as well as negative impacts on the environment and economy. Therefore, the species creates inconveniences between various groups in society (Vitkova 2017). Negative environmental impacts of black locust has been a problem that is stressed by environmentalists. On the other hand beekeepers, some foresters, urban planners value highly its strengths. Due to this negative effect and since it was commonly used in many countries, there has been studies made on management methods among Central European countries. These studies try to find some balance in approach to black locust that would minimise the hazards to environment and maximize the benefits that could result from its responsible use (Sádlo et al., 2017). Since it is in the list of invasive alien tree species, there have been management measures that include prevention, early detection and fast eradication are allow for the control of black locust. To control, reduce and mitigate the negative impacts of invasive alien species such as black locust and their usage, there was regulations that it has been decided by Council of Europe. Currently in many European countries, applications of coppice management is favourable against spread of black locust to deciduous forests. It has been considered as a much-preferred method to the clear-cutting method. Since it can easily escape and counties its invasion within maximum approximately 50 meters after 20 years, due to this fact biomass production should be carefully managed (Vítková et al., 2017; Crosti et al., 2016; Sitzia et al., 2014). On the other hand, some authors (e.g. Ambrass et al. 2014) call attention to the fact that low forest or forest combining coppice with standards may promote undesirable spreading of the light-demanding black locust as the light input is higher and rotation shorter in such forms of forest than in high forest.

Sádlo et al. (2017) define various approaches to black locust management according to the situation. Several examples are mentioned below.

For the *regularly managed black locust forests* with monospecific tree layer, restoration of native vegetation is difficult and time-consuming. Because of the high sprouting ability of *Robinia*, it is hazardous. Silvicultural management may be an adequate choice.

Regularly managed mixed black locust forests (combines alien and native trees) is known as the most common forest type in Europe. This type usually occurs in open woodlands or previously deforested and disturbed sites. These black locust forests are usually sustainable, profitable with low risk. As for management, selective cutting that reduces light availability and favours native tree species is desirable in such mixed forests. However, efforts to eradicate all Robinia trees would be troublesome.

Unmanaged old black locust stands usually occur in the Czech Republic and Switzerland on sites with slopes. Maintenance or restoration with native species would usually be complicated. Slow conversion to the close-to nature forest through natural succession is recommended if possible.

Young Robinia stands spreading into vulnerable habitats is an example of a black locust community that is extremely dangerous to the environment. The spread should be restricted if *Robinia* stands occur in or adjacent to fallow land, grassland or other habitats with rare native plants. The eradication of black locust should be rapid and persistent, although expensive and risky.

Figure 12. Characteristic traits of black locust stands planted on steep slopes in Bohemia (photo: Ivan Kuneš, 2019) (Kuneš et al., 2019).

Briefly, the conflicts such as loss of biodiversity in black locust stands, cost-benefit analysis, damage to cultural values, benefits to economic value and conservation value of adjacent areas like urban, industrial and natural areas are considered as potential threats with spreading across world and inappropriate management to this spreading. Different management methods have been taking into account to find a solution for the conflicts between beekeepers, forestry, urban landscaping and nature conversation due to these positive and negative effects of black locust on ecosystems. Therefore, there have been several management options and according to its invasiveness around world more attention will be given in future for the different types of black locust stands (Sádlo et al., 2017).

1.10.1.Silviculture of black locust

Growing space index is a good method to find right thinning intensity, it takes account the mean distance between trees as a percentage of mean height after thinning. For the black locust, this index is around 23–24% (Rédei et al., 2011).

In terms of afforestation and reforestations, different approaches and preparations are required to estimate the management method. The establishments of the black locust are carried out for afforestation and reforestations. Deep soil loosening is one of the afforestation operations that involves machine for the planting and soil preparation without trenching as well as with deep ploughing and trenching. When the black locust stands reach 10–15 years of age, it shows a full canopy. When required light demand is met black locust can show great growth after 10–20 years with tending. Height growth of black locust occurs in the first 5 years, in 20 years of age annual volume increment reaches the highest, for annual volume increment this age approximately 35–40 years (Nicolescu et al., 2018).

Figure 13. In terms of cover and light availability under black locust stands (left) and native hardwood canopy (right) (Deneau, 2013).

Due to previously mentioned facts when the canopy is closed and there are height differences between trees, the negative selection was the best option for black locust stands. In Hungary, negative selection has been applied when the coppiced stands are 3–6 years old. For the Hungarian black locust stands, artificial pruning is very important for the quality improvement purposes (Nicolescu et al., 2018). In Romania, release cutting are applied as tending operations to avoid dominance of stump stools over root suckers.

1.10.2.Black locust in forest nurseries

To provide favourable conditions and an optimum care and attention to seedlings during their juvenile stage gives and positive results for the production of healthy seedlings. Forest nurseries spread across the whole Europe and Asia for the growing planting stock of trees and shrubs. In the nurseries black locust seeds should be covered 6 mm layer of soil during sowing. Sowing of seed occurs in spring (between April and May) to avoid frost damages from late frosts., nursery production can be carried out on loam or sandy loam soils with pH of 5.5–7.5 to obtain high-quality black locust seedlings. Potassium and phosphorus content for the soil is optimal 15–20 mg for phosphorus and 10–15 mg for potassium per 100 g. Chemical fertilisers should use for soils poor in potassium and phosphorus (Nicolescu et al., 2018).

Preparation and cultivation of soil play a vital role in producing of good quality seedlings. Ploughing at a depth of 35–40 cm after application of fertilisers in autumn increases the chance of successful seedling producing. To avoid the weed and nematode infection, soil should be sterilised. After 1 year when the seedlings have reached a minimum 6 mm in diameter, planting stock is ready for out planting (Nicolescu et al., 2018).

Medium and poor quality of soils has been a good establishment place for black locust forests in Hungary. The soils with adequate moisture, rich in terms of nutrients and humus and well aerated are the best option for the producing good quality of timber. Medium and poor quality of soils are good for the production of fuel wood, fodder, poles and honey production as well as environmental and soil protection and improvement purposes (Rédei et al., 2011).

1.11. Invasiveness of black locust in Europe and Asia

Migration of species to different region or continents from their native boundaries is a result of human activities and desires. But invasive species defined as the species spread further without human activities in the ecosystem. This invasive species called as weeds or weedy plants can be shrubs, plants on agricultural fields or tree species. Invasive species has an undesirable and negative effects on ecosystems usually during early stage of plant successions. (Rejmánek, 1989 in Deneau, 2013). Less competition is a favourable factor to grow and reproduce quickly for the invasive species (Deneau, 2013).

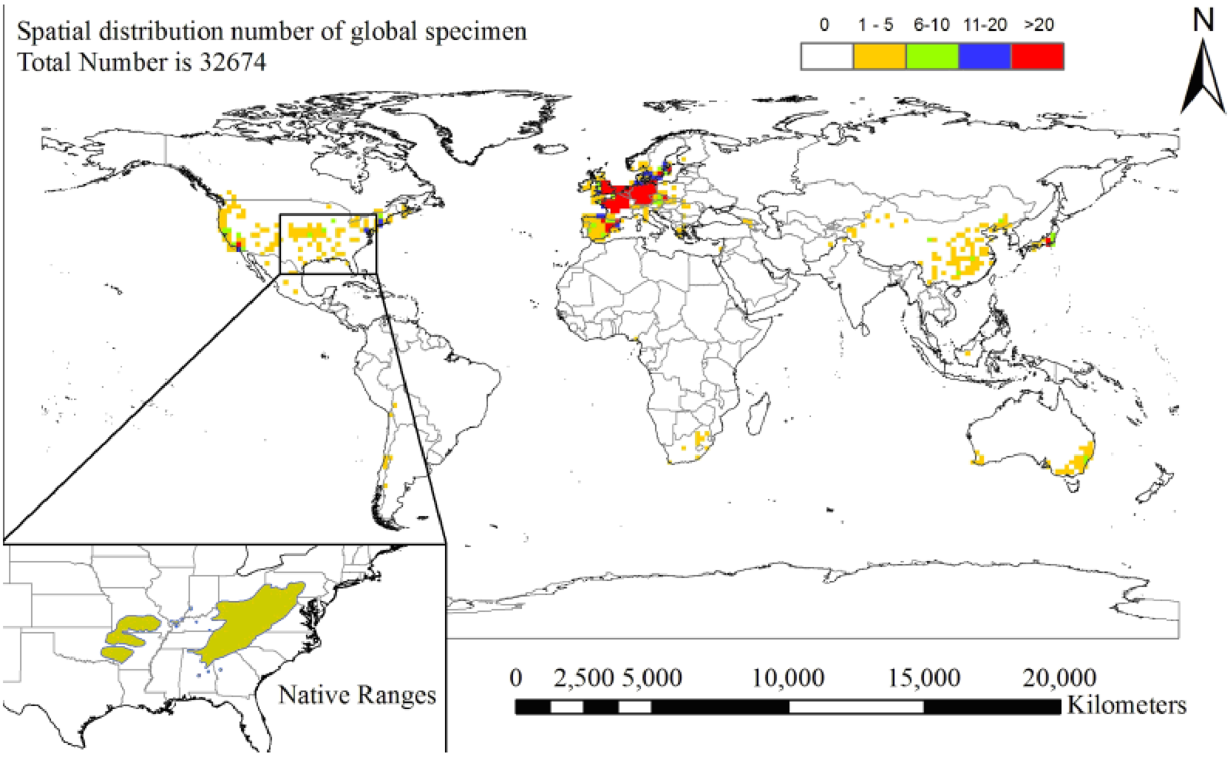

Figure 14: Invasiveness of black locust European Countries (Li et al., 2014).

There are many alien/non-native to Europe tree species and these trees are have a potential to become invasive. This invasiveness can have positive and negative effects on ecosystem. Black locust is an alien tree from its native range North America. It has been planted to worldwide. For its ability of fast growing and resistance to lack of water and rot, black locust has been used in many areas from firewood to erosion control. In Europe, it has been used as afforestation purposes in large scales in between 19th and 20th centuries (Sádlo et al., 2017).

In the beginning, black locust was appreciated for its favourable qualities and negative impacts were not recognized. At that time, black locust became a popular tree species planted in many habitats such as lowlands deforested areas and abandoned pastures. Recently the stands of black locust has been often converted to the local native trees (Sádlo et al., 2017).

Outside of its native range, in Europe and Asia, where climatic conditions are different, black locust was successfully introduced. However, soon the tree became an invasive species (Huntley, 1990). Introduction of black locust to Europe has an important effect on wide spreading in Central Europe in the late eighteenth and early nineteenth centuries. Black locust is now widespread all around Europe from Italy to Norway. Due to this spread, black locust is the most used native North American tree species in the Europe with approximately more than 2.5 million hectares (Sitzia et al., 2016; Nicolescu et al., 2018).

As one of the most invasive woody angiosperms, black locust belongs among the 100 most invasive alien species in Europe and Asia. Black locust has been listed as highly invasive tree species in several databases (EPPO, ISSG and DAISIE). It is one of the tree species ranked with highest negative impact in Europe and it has been listed among Black List in many countries (Sádlo et al., 2017). On the other hand, only 17 out of 35 European countries officially report black locust as invasive (Nicolescu et al., 2018). In many European countries the species is included to forest schemes.

Another reason for the rapid spread of black locust happens with root suckers. Root suckers usually grow from the buds of the trees or shrubs. (Carl et al., 2019).

It has been recorded that after clearcutting on a mixed hardwood stand, 30 percent of woody stems taller than 1.4 m were black locust. Due to this fact black locust considered as a weed species and a strong competitor against more desirable tree species by forest managers (Huntley, 1990).

On the other hand, the undesirable spread was minimal in the orchards and negligible in semi-natural woodland in Italy (Crosti et al., 2016). The areas such as thermophilous grasslands, dwarfed thermophilous pine and oak forests are the most vulnerable to spread of black locust in the Czech Republic. Silvicultural techniques such as coppicing may encourage the undesirable spread of black locust (Vítková 2014; Kunes et al., 2019). Black locust has a higher survival rate in sparsely vegetated sites when we compare with densely vegetated sites (Huntley, 1990).

Control and eradication of black locust in the areas where dense sprouting thickets or large populations dominated by black locust can be taken under control with spraying with herbicides. High pressure spray systems are suggested as an efficient for application of herbicides in dense thicklets (Heim et al., 2017 in Kuneš et al., 2020). When black locust rejuvenation through resprouting is undesirable after cutting trees, immediate application of herbicides on cutting surface of the fresh stumps can be used (Vítková, 2011). More specifically, with the increasing density of black locust, management methods can be insufficient. This density has been controlled by frill treatment with 2, 4, 5-T and glyphosate gave successful results against control of black locust in Christmas tree plantations in Maryland (Huntley, 1990).

Due to climate change, further expansion of black locust is expected in forest and non-forest areas. This expansion may unfavourable for foresters because black locust is extremely difficult to control even with different kind of methods such as herbicide application after cutting the stump, pulling with hand and repeated girdling. Also costs of applications are not low and often do not give successful result (Straker et al., 2015) at least after single treatment (repeated treatments and check of the results is necessary).

While some studies take into account the black locust as an alternative tree species to European ash (*Fraxinus excelsior*), that is damaged and suffered by the fungal pathogens, other studies declared black locust as an invasive nonnative tree species in Europe and Asia (Vítková et al., 2017; Carl et al., 2019).

1.12. Impact on plant diversity

The forest with high productivity and biodiversity and with large and variable number of species called mixed mesophytic forests where black locust grows and develops very well are in central and south part of Appalachian region. Due to this fact black locust is listed as a component of these kind of forests. In America, beside of being competitive tree species, black locust may be well associated with yellow-poplar and yellow-poplar-white oak-northern red oak (Huntley, 1990).

The rapid growth rate gives an ample opportunity to black locus to compete with other dominant tree species such as maple (*Acer* spp.), ash (*Fraxinus* spp.) and beech (*Fagus* spp.) outside of its native range in North America (Deneau, 2013). Lack of plant growth underneath of the canopy may be the result of the phytotoxins in leaves and other allelochemicals in other parts of the tree. Black locust can also create too much shade for some understory vegetation (Deneau, 2013). In southern part of Appalachians, dense black locust stands occupy at least 15 percent of the area and compete with more desirable tree species and effect their growth rate (Huntley, 1990).

For timber production, black locust is usually planted in pure stands on sandy soils. However, in Hungary it has been often grown in mixed stands with white poplar (*Populus alba*). In Romania, it was grown with black cherry (*Prunus serotina*). On mining wastes, black locust has been planted with common ash (*Fraxinus excelsior*).

Figure 15. 53 years old mixed black locust (BL) and black cherry (BC) stand in Romania (Nicolescu et al., 2018).

According to some authors, in 10–36-year-old stand of black locust and native pioneer stands, there were no difference in terms of richness and diversity for the understory vegetation in the Eastern Alps (Sitzia et al., 2012). However, lower alpha diversity (the mean species diversity in the habitats at a local scale) has been recorded in black locust stands when it is compared to the native *Betula pendula* stands in urban areas in Berlin (Trentanovi et al., 2013). In northern Indiana, it has been recorded that natural diversity of herbaceous plants in *Quercus velutina* populations was reduced by black locust (Peloquin and Hiebert, 1999).

Black locust creates a homogeneous forest plant layer in Northern part of Apennines Mountains in Italy (Benesperi et al., 2012). Rapid spread of black may affect the composition of lichen communities and promote the species tolerant to air pollution and eutrophication adapted to dry conditions. Black locust usually changes the conditions for understory vegetation and provides suitable conditions for the shade tolerant and/or nitrophilous species such as *Alliaria petiolata*, *Anthriscus sylvestris*, *Gallium aparine*, *Sambucus nigra* and *Urtica dioica* (Vítková and Kolbek, 2010).

During the growing season, black locust stands have more open shrub and herb layer when compared to native forests. Canopy cover in black locust stands is 57% compared to 72% in native oak forests. Due to these facts, shrub coverage in black locust stands is 57% and 11% in oak forest, herb layer coverage is 53% in black locust stands and 5% in oak forests (Hanzelka and Reif, 2015).

The leafing period of black locust starts late in spring, mostly during May, fall of leaves begin mostly during summer droughts. Due to this fact the growing period of black locust is quite short.

For the light demanding species or dense shrubs, black locusts crown transparency makes the conditions that are more favourable then in stands of other species. However, this situation is unfavourable for some native tree seedlings. In grasslands and open habitats, dense populations of black locust create unfavourable conditions for the heliophilous plants (Vítková and Kolbek, 2010). In dry or semi-dry grasslands and on some of the species rich habitats, black locust invasion coses extinction of many light demanding plants with changes in climatic, light, microclimate and soil conditions. Therefore, spreading of black locust on such sites is a problem for nature conservation if local, native rare species are present.

As for the effects of black locust on soil properties that was mentioned on previous chapters, it can negatively affects some plant communities causing the eutrophication and acidification and decrease of the amount of microorganisms during the seed reproduction process (Kolbek et al. 2004; Vítková, 2014; Kuneš et al., 2019).

1.13. Multi purposes of black locust

Once black locust was discovered by European settlers, it started to be used for fence posts, mine timbers, poles, railroad ties, insulator pins, ship building material and tree nails for construction of the ships, fuelwood, crates and boxes. Farmers discovered, that black locust can be used for the erosion control, stabilization of the eroded hillsides, soil improvements and provision of quality timber. The tree can be planted on poor soils, in windbreaks, nurse crops and for honey production (Keresztesi 1980; Boring and Swank 1984; Huntley, 1990).

Also, the scientists concluded that black locust might be suitable for planting on loose sand and mine wastes, where erosion was needed to be taken under control and reforestation management was desirable (Deneau, 2013).

Besides having important attributes as nitrogen-fixing and erosion control ability, black locust has gained an important place by its use for many other various purposes. More specifically, it has rapid growth rate, biomass production, high quality wood, ability to improve nitrogen amount in the soil, resistance to drought, high temperatures and air pollution. It provides nectar for the honey-production (Rédei et al. 2011; Kuneš et al., 2019).

In the Czech Republic and Switzerland, black locust was used as a stabilisation tree for the deforested steep slopes (Kolbek et al., 2004). Recently, protective forests are considered not as strong as they were in the beginning and start to show stability problems as these stands grow old. This kind of forests are usually identified as unmanaged and old forests.

The potential usage of black locust in post mining areas has been recorded during the 1970s and currently black locust still used for this purpose in Poland and Germany. There has been an increase observed for the land use of both forest and agricultural areas for the dendromass production in Central European countries such as Hungary, Poland, Germany, Slovakia and Austria (Grünewald et al., 2009; Rédei et al., 2008). Nitrogen fixation and high drought tolerance predestine black locust for dendromass production on post mining areas with waste soils (Grünewald et al., 2009). One of the most important advantages is a large yield of dendromass within a short period of time about 3–5 years. However, irregular coppice stands when it is compared to optimised plantations have been considered as disadvantages of such forests. After two rotation periods, it was observed that topsoil is exhausted and declined in productivity due to low production of litter and periodic removal of organic matters in the plantations. (Vasilopoulos et al., 2007).

It is used for reclamation of surface mines and serves for fencepost production also in the United States of America (Eigel et al., 1980; Zimmerman and Carpenter 1980). Another important attribute of black locust is the considerable amount of foliage and biomass it creates.

1.13.1. Economic purposes and the important traits for economic income

Due to previously mentioned traits of black locust, it is considered as an economically important tree species in the world (Keresztesi, 1988; Rédei et al., 2008). Currently, black locust provides many ways of usage, from furniture making to as playground equipment. Black locust is valued as a decorative component in gardens, urban streets and parks. The use of black locust in urban areas, parks and street avenues has been very common recently. This is not only for its attractiveness but also the ability to tolerate high levels of air pollution, drought, light intensity and low soil quality.

In terms of economic importance, black locust became the most commonly used non-native/alien tree species in Europe. More specifically, it is an important tree species in Hungary due to providing 25% of annual timber production. However, in other Central European countries it has been only used in small scale of honey production, firewood and other special purposes. As a result of high importance of black locust in Hungary, one third of the black locust forests are plantations which have been planted from seedlings and rest of it is coppiced.

In Slovakia, proportion of productive forests of black locust is very low and approximately 5% of black locust forests are considered as most productive and these are regenerated by coppicing, rest of the 95% of black locust forests have very low quality.

There have not been any new plantations on forest land in the Czech Republic and Switzerland. Due to this fact, coppicing from existing stands are much preferable for the countries, in order to reduce the costs and maximize the revenue (MZE, 2014). Short-rotation plantations are preferred to long-rotation plantations due to optimal harvesting for farmers needs in Poland. Establishment of monospecific black locust stands in different variety of soils effect the soil chemistry and water availability and these changes become a limiting factor for the growth of black locust trees. In order to make benefits the trees that grow up to 10 meters are selected for firewood, honey production and the trees that grow up to 35 meters are usually considered for the quality timber production (Rédei et al., 2008). New clones and cultivars haven been bred for the high volume good quality industrial wood in Germany and Hungary as a result of research programs in 1950s and 1960s (Keresztesi, 1988).

In Hungary, more specifically in the Nyirseg region in terms of yield call I-IV the current annual increment reaches the maximum approximately 17.5 $m^3.ha^{-1}.yr^{-1}$ at age of 10 years and 4.2–6.2 $m^3.ha^{-1}.yr^{-1}$ at age of 15 years as a result of being fast growing tree species. Black locust also able to quickly close canopy openings due to fast growing.

Despite durability of wood, the marketability of black locust timber tends decrease if a proper silvicultural management has not been applied to the *Robinia* stands. Due to this fact, at 3–6 years of age cleaning applications with coppice origin should be applied to reduce stockings. Another application can applied as thinning to reduce density of forests.

1.13.2.Honey production

One of the reasons for which the black locust has special place in Hungary is honey production. The honey production derived from black locust is very common and has an important economical role in the country (Rédei, 2013; Carl et al., 2019). Beside of the use of black locust in the post mining areas and on extreme dry sites, black locust also helps to honey production with the great quality of honey. The honey that it has been produced by flowers of black locust has colour between pale yellow and greenish yellow. It can stay uncrystallised for 3–4 years due to high fructose content (Farkas and Zajácz, 2007).

Approximately 418 kg ha/year honey in Hungary and 100 kg ha/year honey in Poland can be generate form black locust trees, depending on the age of tree (Keresztesi, 1988). More specifically, with approximately 25.000 t/year, Hungary takes the first place on honey production. Which is considered as the highest amount black locust honey production in Central Europe, with representing about 40–50% of European production (Farkas and Zajácz, 2007; Rédei et al., 2011).

1.14. Important role on different countries; Hungary, Romania, China, Turkey etc.

For a long time, black locust was in a dilemma due to its economic importance and its negative impact on biodiversity. Besides of its negative effects on environment and biodiversity, black locust had many countries who appreciate its economic value. It became very popular across Europe and Asia, it has been part of cultural values, songs, literature as well as culinary recipes. Due to this popularity, it has been listed as an unofficial national tree especially in Hungary (Sádlo et al., 2017).

In countries such as Hungary and Romania black locust play an important role in forestry and forest economy. On the other hand, in the Czech Republic due to its invasiveness black locust is not included in forest planning scheme at present (Vítková et al. 2017; Keresztesi 1983; Rédei et al. 2011). Due to its important role and popularity in Hungary, the forests area of black locust was more than in all other European countries. Environmental value, popularity and usage of black locust products in Hungary, it has been estimated that approximately 720,000 hectare of agriculture fields are expected to be used for afforestation in the next 50 years. Environmental value of black locust puts it in an important and strategic place for the environment and life of populations in Hungary (Rédei et al., 2008; Nicolescu et al., 2018).

In Romania black locust stands are considered and managed as coppices. One third of the locust stands were high forests and the rest of them were coppice stands in 1975 (Keresztesi, 1988; Nicolescu et al., 2018). Introduction of black locust to Romania was from Turkey in 1750s. Black locust has been introduced and planted into all regions in Romania but most important regions are Baraganului Plain-Oltenia in the south, Careiului Plain in the north-west between the 1850s and 1890s. In Hungary the ratio of distribution of black locust stands are same as Romania. As mentioned before, black locust stands has important economical role in Hungary due to providing annual approximately 20% of timber supply. Beside of timber providing, black locust was planted afforestation purposes in the abandoned agricultural lands (Haralamb, 1967; Nicolescu et al., 2018). There are many regions in Hungary that has important place for growing of black locust, especially Transdanubia, the Danube-Tisza Interfluve and north east of Hungary (Nicolescu et al., 2018).

Hungary and Romania became the “second home” for black locust with its distribution in the past and current. Due to this distribution propagation, site requirements, management and improvement of black locust, usage of black locust widely used and accepted by Hungarian and Romanian foresters. High adaptability and high expansion rate of black locust made it an important for land reclamation. Traits of adaptability to poor soils with high temperature gives an important place to black locust in future for climate change. It has been growing more than 250 years in Hungary. Currently black locust covers approximately 23% of forested land in Hungary and 4% in Romania and continuously increasing (Rédei et al., 2014; Nicolescu et al., 2018). In Europe, many varieties of the black locust have been recognised. In Hungary, forty-nine varieties were tested and new tests are continuing. Many studies in this regard have been conducted in Korea (Huntley, 1990).

In the past years, plantations of black locust have been widely increased in the Loess Plateau. Since the Loess Plateau is the world's largest plateau located in China (Qiu L, et al., 2009), soil and water conservations carry important role. With the soil improving properties of black locust, it gains an important role in land use and ecosystem management in area of Loess Plateau. The changes have been observed in the soil properties in Nanxiaohe and Wangdonggou watersheds. Black locust significantly increases the cation exchange capacity, organic carbon, total nitrogen in depth of (0-20 cm and 0–80 cm) soil. It was estimated that with increasing black locust age the effects of black locust on soil would increase. Due to this fact, black locust has the potential to improve soil properties in the loessial region of Loess Plateau.

In Turkey, the importance of black locust has been accepted and little studies made to estimate the importance of black locust for future. One of the most important study considered the use of black locust as a biomonitor of heavy metal pollution. In order to estimate air pollution in selected areas, studies were made on leaves and soils samples. As a result, it has been concluded that black locust can be useful as biomonitor in Turkey, Asia, Europe and Africa as well as in its native range in the United States of America.

In Germany (Grünewald et al., 2009), black locust has been recognised for its important features in the country and experiments were launched to improve economic purposes. In terms of short rotation period, the duration of plantation and the harvesting costs are positive effects to economic income. Due to this fact, the cultivation of black locust has been considered important for the future land use on post-mining landscapes.

In Greece, few studies has been done. However, it has been estimated that the black locust has important place for the restoration of degraded crops lands with its soil improving properties (Papaioannou et al., 2016).

Many studies and management improvements advert to the importance of black locust. Fast spread of black locust can be expected in future in many countries such as Spain, Turkey, Greece, China and Korea (Rédei et al., 2011). However, still in many countries black locust could not be accepted for the forest schemes due to the effect on other most desired tree species.

1.15. Pests, diseases and abiotic damage agents

Pests, fungi, diseases and game are the main damage agents in forests for the trees. Big or small game can damage the trees such as fraying, stripping etc. Pests and fungi can damage the trees that were weakened by game.

In this particular section damage agents of black locust are briefly summarised.

In its native range, black locust is one of the most damaged tree species by disease and insects. Locust borer (*Megacyllene robinae*), heart-rot fungi and witches broom viruses often destroy any valuable locust timber and prevent the black locust from becoming one of the most valuable timber species in the United States of America (Barrett et al, 1990; Boring and Swank, 1984; Deneau, 2013). The locust borer (*Megcallene robiniae*) comes in the first place who does make damage to black locust and effects its timber production negatively. *Phellinus rimosus* and *Polyporus robiniophilus* take second place as damage agents. Both of the damage agents have a negative effect on timber quality and cause wood decay. Through the feeding tunnels and holes on wood caused by locust borer larvae, heart rot fungi can enter the wood and cause significant damage to timber quality (Huntley, 1990).

Figure 16: Megacyllene robiniae (Locust borer) and Phellinus pomaceus, as damage agents of black locust (Wikipedia, 2021; accessed on 2021/04/19)

There are many other damage agents that effect black locust in many different ways. *Odandata dorsalis* known as locust leaf miner cause defoliation and occur almost every year. Due to this defoliation, it gives opportunities to other damage agents to attack black locust. Another damage agent is *Eedytolopha insiticiana* may cause high seedling mortality in the areas heavily infested. Additionally, there are common diseases such as heart rot and witches broom, considered among other damage agents of black locust.

Interestingly, outside of America, black locust is considered as resistant to pest and diseases. However, seeds and seedlings have been damaged by several fungi and insects such as *Fusarium oxysporum* and *Aphis fabae*. Game damages by rabbit and deer are also not negligible (Huntley, 1990).

In Central Europe, abiotic stresses such as early and late frosts are critical for black locust. The late spring frost has been limiting factor for black locust growth also in the United Kingdom and Ireland.

Figure 17: Robinia pseudoacacia L. (Black locust) with frost damage in United Kingdom and Ireland (Milton Keynes, 2020).

2. Focus on chosen sources from the literature

The following chapter focuses on methodical approaches of studies assessing black locust from various points of view.

Carl et al. (2019) published a study on estimation of spreading and reproduction of black locust from seed, stump shoot and root suckers in short-rotation coppices in Germany. In total, ten study sites were selected.

Germination success has been observed for the different types of stratification methods. Stump shoot analysis has been based on the number of shoots per stump, site and age class. For the spreading analyses UAS (Unmanned Aerial Systems, i.e. a drone) has been used. Two eight-year-old *Robinia pseudoacacia* short rotation plantations has been selected for the collection of seed and it takes places in winter at year of 2016. More specifically, plantations are from town of Lauchhammer and village of Röblingen. Seven study sites have been selected for the stump shoot sample collection during the November in 2016 and during March in 2017.

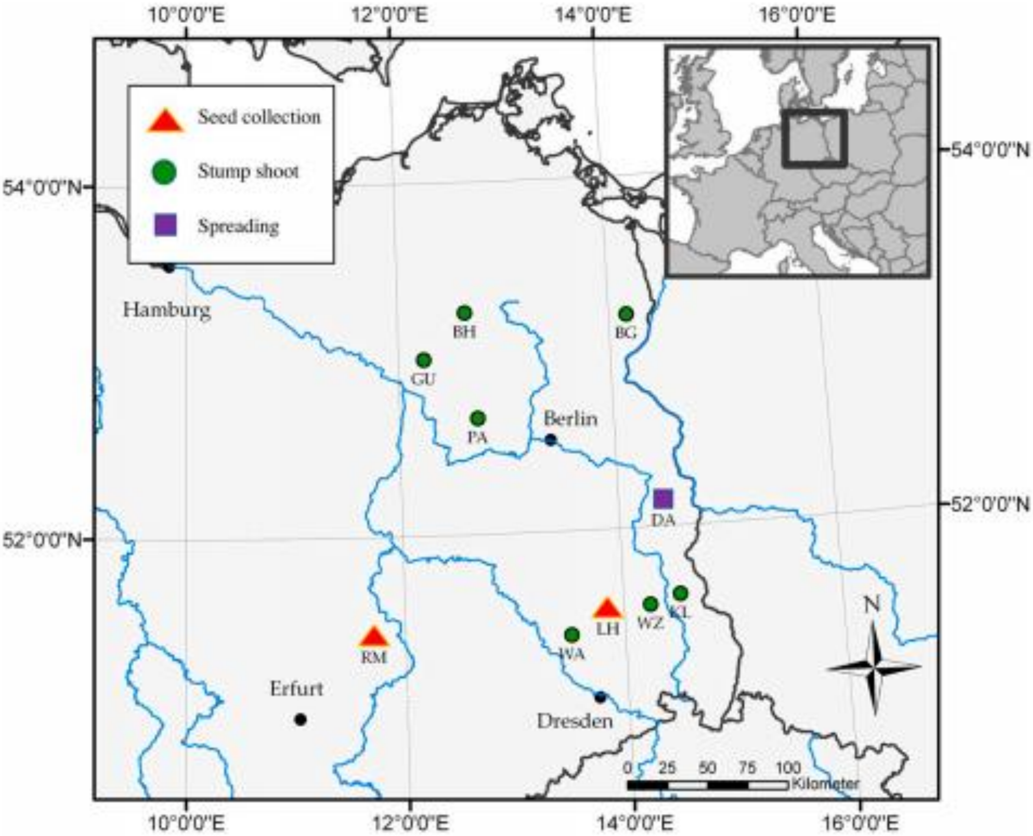

Figure 18. Study sites in Germany for the purposes of seed collection, stump shoot and spreading (Carl et al., 2019).

The selection of stump shoots was located in area of Blumberg (BG), Buchholz (BH), Gumtow (GU), Kelin Loitz (KL), Paulinenaue (PA), Wainsdorf (WA), Welzow (WZ) in Germany. For the spreading analysis area of Grunow-Dammendorf (DA) has been selected.

In total 3000, seeds have been tested with six different treatment methods and seed were seed to sand mineral soil in boxes.

Following different pretreatments were tested:

- Seeds were seeded and water was given
- Water-soaking for 24 hours was applied (water temperature was 18 °C) then seeds were sown and watered
- Temperature treatment was applied within short period of time, stored in air temperature 45 °C for two hours then stored in -20 °C for another two hours then seeded
- Temperature treatment was applied within short period of time, stored in air temperature 60 °C for two hours then stored in -20 °C then seeded
- Hot water treatment has been applied
- Mechanical scarification has been applied

For the stump shoot analysis, 5244 stump sprouts were analysed in total. For the estimation of number of sprouts per stump, site and age class number of established and planted black locust trees were the main criteria.

Vitková et al. (2015) assessed *Robina* invasion in relation the soil characteristics. Study took place in the Czech Republic. The annual temperature was between 6.6 and 9.1 °C, annual precipitation 494–380 m a.s.l. and slope between 0–50 °C. As study areas 33 research plots with (area 250 m^2) were selected and established between 1997 and 1999. Ellenberg values have been used for determination of nitrophilous species. Unmanaged successional mature 40 years old black locust stands were selected where stands are growing in open landscapes.

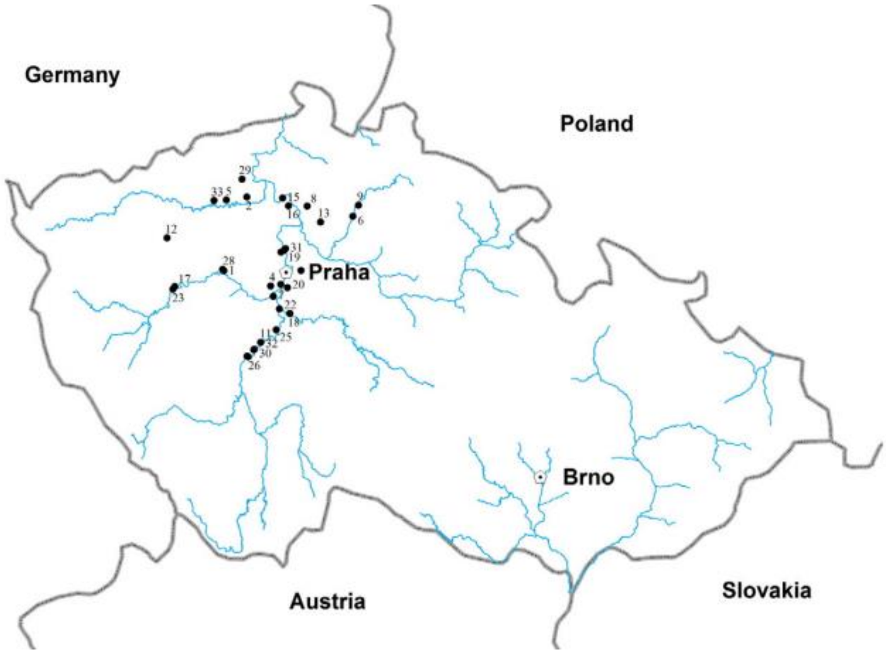

Figure 19: Black lcoust stands and their distribution on selected study area in Czech Republic (Vítková et al, 2015)

To describe the soil characteristics, samples were collected from each plot. From each plot samples of bedrocks, soils and lumps of soils were collected. Sample collection occurred twice, at the beginning of growing season in mid April 2000 after a cold and wet spring and at the end of the growing season in mid September 1999 after a dry and hot summer. Each sample consisted of 1 kg of soil. Determination of ammonium and nitrates started on field when the soil was fresh with 2 mm sieve before the soils sample transported to the laboratory. Air-dried fine earth was used for the analyses of pH, carbonate concentration, total carbon and nitrogen and nitrification. For the determination of soil moisture and dry matter, fresh unsifted soil samples have been taken with bags from field. Stoniness of the soils has been calculated in percentages.

For the calculation pH, methods of Moore and Chapman (Moore and Chapman, 1986) were used by using titration and atomic absorption spectroscopy. Total carbon and nitrogen have been analysed according to combustion of soil followed by determination of oxides. Organic carbon was calculated according to difference between total carbon and carbonate carbon. Measurement of nitrogen mineralisation and nitrification takes places in aerobic laboratory incubators for 28 days.

Number	Type	Syntaxon	Soil type	Bedrock	Altitude	Slope	Aspect	Annual precipitation	Annual temperature
1	Species-rich nitrophilous	*Chelidonio-Robinietum*	Eutric leptosol	Spilite	310	30	203	541	7.9
2	Species-rich nitrophilous	*Chelidonio-Robinietum*	Eutric leptosol	Basalt	360	35	158	539	7.5
3	Species-rich nitrophilous	*Chelidonio-Robinietum*	Rendzic leptosol	Diabase	285	30	158	495	9.0
4	Species-rich nitrophilous	*Chelidonio-Robinietum*	Rendzic leptosol	Limestone	315	30	180	511	8.4
5	Species-rich nitrophilous	*Chelidonio-Robinietum*	Rendzic leptosol	Olivine basalt	270	10	135	532	7.8
6	Species-rich nitrophilous	*Chelidonio-Robinietum*	Calcic leptosol	Calcareous sandstone	240	40	180	530	8.3
7	Species-rich nitrophilous	*Chelidonio-Robinietum*	Cambic leptosol	Paleozoic schist	220	35	158	496	9.1
8	Species-rich nitrophilous	*Chelidonio-Robinietum*	Arenosol	Quarzite sandstone	210	30	113	513	8.2
9	Species-rich nitrophilous	*Chelidonio-Robinietum*	Lithic cambisol	Calcareous sandstone	240	30	203	535	8.2
10	Species-rich nitrophilous	*Chelidonio-Robinietum*	Dystric cambisol	Quarcite	240	20	158	494	9.0
11	Species-rich nitrophilous	*Chelidonio-Robinietum*	Dystric cambisol	Quartz diorite	280	25	158	566	8.5
12	Species-rich nitrophilous	*Chelidonio-Robinietum*	Fluvisol	Carbon-Permian sandstone	330	30	225	577	7.6
13	Species-rich nitrophilous	*Chelidonio-Robinietum*	Fluvisol	Calcareous sandstone	230	20	180	508	8.4
14	Species-poor grassy	*Arrhenathero-Robinietum*	Arenosol	Eolian sands	150	0	–	498	8.6
15	Species-poor grassy	*Arrhenathero-Robinietum*	Arenosol	Eolian sands	150	0	–	498	8.6
16	Species-poor grassy	*Arrhenathero-Robinietum*	Arenosol	Eolian sands	190	0	–	507	8.3
17	Open and mesic	*Poo-Robinietum*	Typic leptosol	Proterozoic schist	290	45	113	573	8.0
18	Open and mesic	*Poo-Robinietum*	Typic leptosol	Amphibole schist	200	35	158	524	8.9
19	Open and mesic	*Poo-Robinietum*	Cambic leptosol	proterozoic schist	210	50	270	498	8.4
20	Open and mesic	*Poo-Robinietum*	Cambic leptosol	Proterozoic schist	280	35	270	511	8.8
21	Open and mesic	*Poo-Robinietum*	Cambic leptosol	Amphibolite	300	40	135	625	7.7
22	Open and mesic	*Poo-Robinietum*	Lithic cambisol	proterozoic Schist	240	45	338	520	8.8
23	Open and mesic	*Poo-Robinietum*	Lithic cambisol	Phylite	350	35	225	586	7.8
24	Open and mesic	*Poo-Robinietum*	Lithic cambisol	Syenodiorite	310	30	203	574	8.5
25	Open and mesic	*Poo-Robinietum*	Lithic cambisol	Amphibole schist	300	40	158	555	8.4
26	Open and mesic	*Poo-Robinietum*	Lithic cambisol	Amphibole schist	350	35	113	604	8.1
27	Open and mesic	*Poo-Robinietum*	Dystric cambisol	Lydite	250	30	113	482	8.9
28	Open and mesic	*Poo-Robinietum*	Arenic cambisol	Proterozoic schist	290	35	203	527	8.3
29	Open and mesic	*Poo-Robinietum*	Haplic luvisol	Basalt	380	20	203	580	6.6
30	Dwarf and shrubby	*Melico-Robinietum*	Lithic leptosol	granodiorite	330	45	90	574	8.5
31	Dwarf and shrubby	*Melico-Robinietum*	Lithic leptosol	Spilite	260	30	203	497	8.5
32	Dwarf and shrubby	*Melico-Robinietum*	Lithic cambisol	Quartz diorite	300	30	158	566	8.5
33	Dwarf and shrubby	*Melico-Robinietum*	Chernozem	Olivine nephelinite	260	25	203	557	7.5

Table 1: Species composition, soil type and bedrock characteristics of black locust stands in Czech Republic (Vítková et al, 2015)

The study of impact of *Robinia pseudoacacia* L. invasion to forest plant diversity was made by Benesperi et al. (2012). Specifically, the changes on plant diversity has been observed with the increasing stand age of black locust. Plant richness and composition have been compared with native trees in selected area.

The study took place in the area of the Northern Apennines in Italy. In terms of climate conditions of the area; elevation ranges between 100 and 900 m a.s.l, mean temperature is between 9.4 and 14.4 °C. Mean annual precipitation ranges between 1300 and 1900 mm.

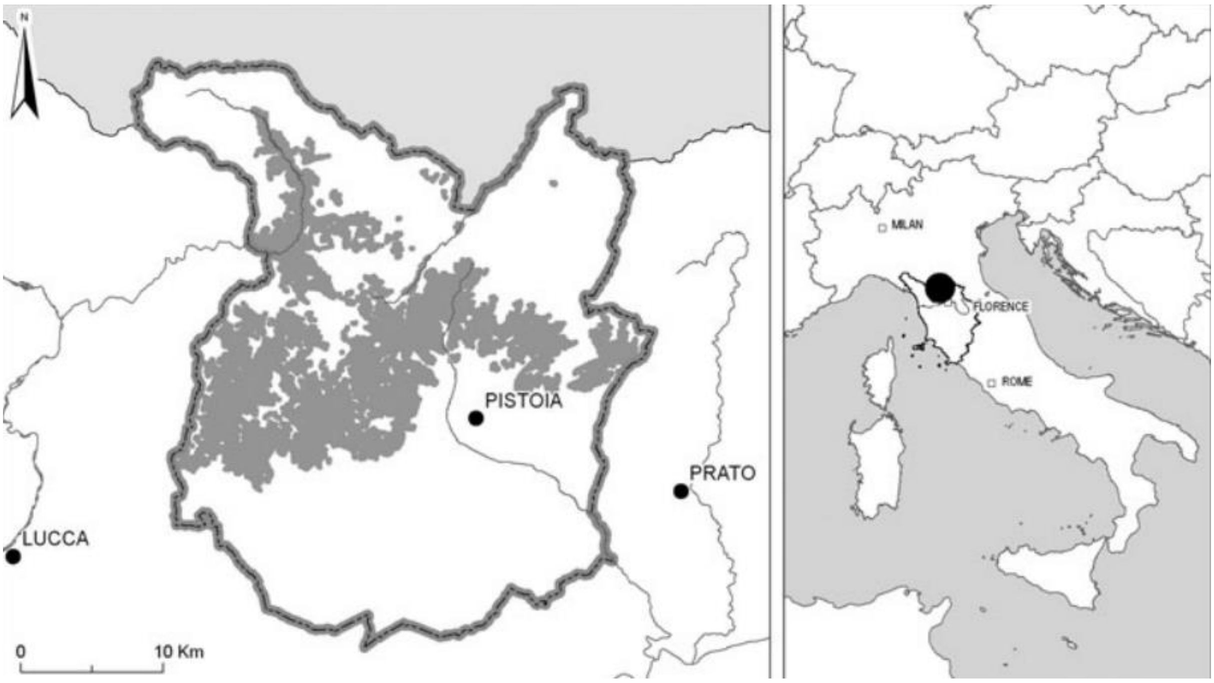

Figure 20: Black locust distribution in selected area (Dark grey color) (Benesperi et al., 2012).

Vegetation composition of the landscape area dominated by olive and vineyards and forest areas dominated by black locust at the lower altitudes. At higher altitudes black locust only occurs in the mixed forest stands with chestnut, oak and hornbeam as coppice purposes (20–30 years rotation cycles). Regeneration of mature stands was usually done with clear cutting.

Due to aim of this study black locust stands classified into three part according to their ages.

- Young stands with approximately 10-year-old trees having a circumference of 20–40 cm at breast height (BH).
- Intermediate (approx. 20-year-old) stands with trees having 40–60 cm at BH
- Mature stands with trees having a circumference of more than 60 cm at BH.

For native species and each type of black locust stands seven 30 m^2 plots have been randomly selected in the area of Northern Apennines. To avoid differences related to soil moisture, elevation and shading such parameters slope, elevation and canopy cover were kept similar for the selection of plots. Distance between plots was approximately 500 meters.

Diameter of all trees has been measured in each plot and abundance of vascular plants recorded within 10 x 10 meter selected subplots in 30 x 30 meter plots. Eutrophication impact of nitrophilous species was defined using Ellenbers values.

The study by Aksoy et al. (2000) took place in the city of Kayseri in Turkey. The aim of the study was using black locust as a biomonitoring tool and the collection of samples in different areas of the city and estimate the effect of air pollution on the leaves of black locust. The areas for sample collection divided to six such as industrial, roadside, urban, suburban and rural areas. For the collection of samples from urban areas, the most crowded sites preferred. The highway between the cities of Kayseri and Kirsehir due to high traffic density (285 cars per hour) was the most suitable for the sample collection from roadside. The area around (approx. 10 m around the industrial plant) the industrial establishment (22 km far from the city center) selected for the collection of samples due to high amount zinc production.

The study are takes place on in Chalkidiki of Northern Greece (Papaioannou et al., 2016). According to land use types and purposes, area divided to three:

- Mixed native forestlands (The area was clear felled due to expansion of cultivated areas)
- Croplands (Has been used only for cultivation purposes especially with wheat and barley)
- Black locust plantations (Has been planted in order to restore degraded croplands)

Besides of the purpose of restore degraded areas, black locust also has been planted for the biomass production due to its adaptation to climatic and soil conditions. Distribution of the three areas 10% black locust plantations, 20% of croplands and 70% of mixed native forests. Climate has the semi-Mediterranean characteristics with the average temperature between 5°C–26°C. The annual precipitation range between 430 to 591 mm.

The mixed forest area mostly dominated by *Quercus ilex, Quercus coccifera* and *Arbutus unedo.* The areas still cultivated with wheat and barley requires N, P and K fertilisation.

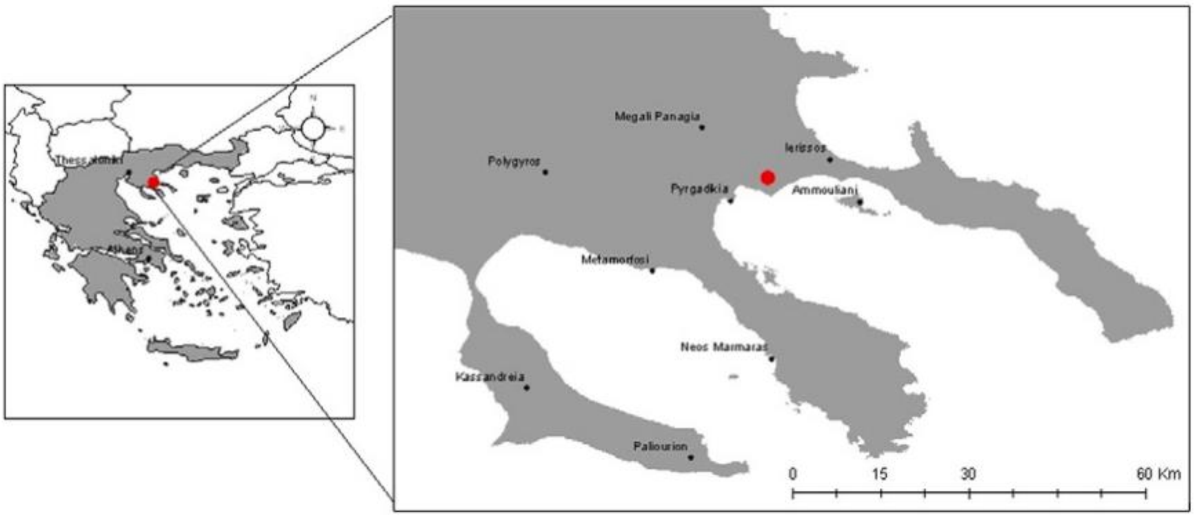

Figure 21: The study area in Greece with the Robinia pseudoacacia L. plantations (Papaioannou et al., 2016).

From selected area, 18 sampling plots have been chosen, six plots from each three area. The area of the plots were approximately 4 ha. Five sampling point have been selected for the soil samples. Soil and leaf tissue of black locust has been analysed.

3. RESULTS

The following chapter focuses on outcomes of the chosen studies assessing black locust from various points of view.

In the study by Carl et al. (2019), the germination rate was dependent on the pretreatment method. Following germination rates were recoded:

- The highest germination rate, approximately 90%, was observed, when mechanical scarification was used.
- As a result of hot water scalding, germination rate reached to 72%
- Germination rate were between 23% and 69% in warm-cold treatments.
- Water treatment (soaking) for 24 hours give 8% of germination.
- Lowest germination 6% observed on the seed where seeds directly sown and watered

See Fig. 23 for further details.

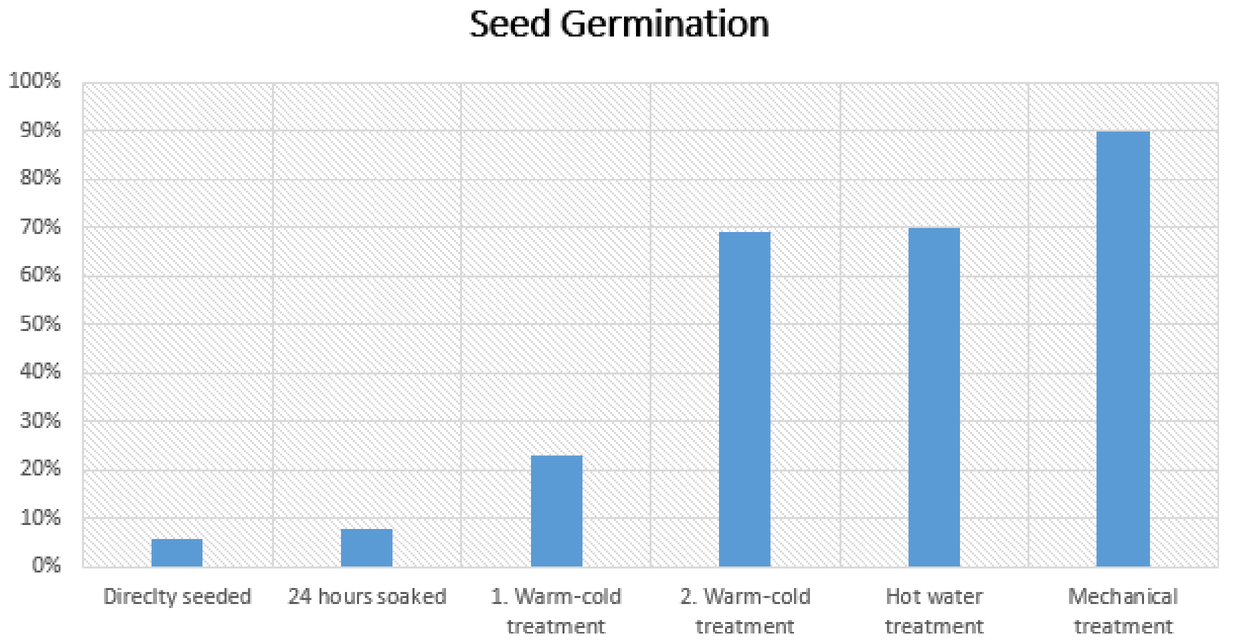

Figure 22: Germination percentage for different treatment and scarification methods (Carl et al., 2019, Modified)

In terms of stump shoot analysis, number of shoots per stump decreased with increasing age. After one year from the harvest, an average number of shoots per stump was 4.17

Second and third year and third year since harvest decreasing number of shoots dropped to 3.6 and 2.18 shoots per stump, respectively.

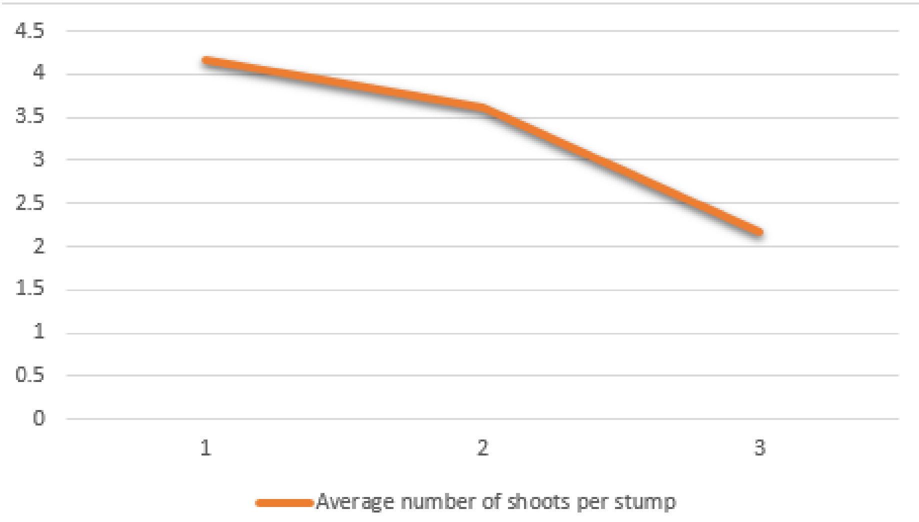

Figure 23: Average number of shoots per stump with increasing age (Carl et al., 2019, Modified).

Root suckering was observed in five different type of areas such as meadow, farmland, dirt road and pine forest. Spreading proportion was divided to five different range as 0–2 m, 2–4 m, 4–6 m, 6–8 m and 8–10 m. The highest average distance, 2.26 m, was reached if the surrounding area was a dirt road. At 1.89 m, the second highest average distance was recorded if the surrounding area is meadow. If the forest was the surrounding area, the average distance is 1.49 m (Carl et al., 2019). See table 2.

Zone	0–2 m (%)	2–4 m (%)	4–6 m (%)	6–8 m (%)	8–10 m (%)	Average Distance (m)
Meadow	43.99	32.37	14.86	3.00	0.33	1.89
Farmland	27.45	19.60	9.78	0.91	0.07	1.16
Dirt road	41.96	37.81	26.07	6.38	0.58	2.26
Forest	40.23	25.42	7.79	1.14	0.002	1.49

Table 2: Average distance proportions for the spreading of black locust in different type of areas (Carl et al., 2019).

As for the study by Vitková et al. (2015), black locust stands tend to grow on young shallow soils in the Czech Republic (Central Europe). Cambisols, Leptosols, Arenosols and Fluvisols can be named. Cambisols and Leptosols are most frequent (See figure 26).

Cambisols are typical soil substrates in the Czech Republic, which explains why these soil support black locust stands most frequently. The calcareous, very shallow and extremely stony Leptosols mostly on the slopes of rivers are the second most common soil type supporting black locust stands. Main reason for this were the erosion control efforts conducted in the past. Prosperuous stands of black locust were on deep and rich

Chernozems, Acrisols and Luvisols. However, the best conditions for the growth of black locust appear to be sandy soils like Arenosols (Vítková et al., 2015).

Some other outcomes of the study by Vítková et al. (2015) from the Czech Republic:

(1) Black locust is able to tolerate very diverse soil physical–chemical properties.

(2) The species is probably limited by the supply of water and soil aeration.

(3) Species composition in the stands of black locust was mostly influenced by soil reaction.

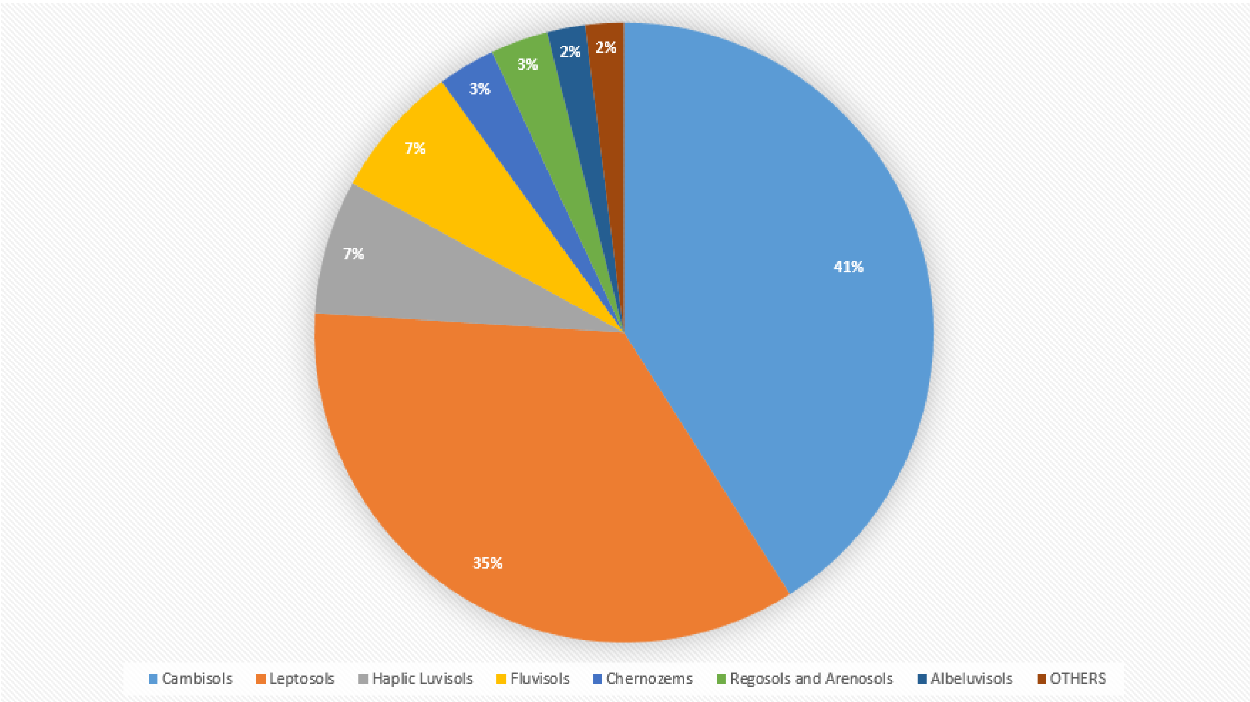

Figure 24: Common soil type's distribution for the black locust stands in Czech Republic (according to Vítková et al., 2015; Modifed).

As for the study by Benesperi et al. (2012) , there were no differences in terms of species richness among three different age classes of black locust stands. However, in terms of species heterogeneity highest value belonged to native forest stands. It was also observed that intermediate black locust stands were more heterogeneous than young and mature stands of black locust.

	BL_Y	BL_A	BL_M	Native	*p*
Vascular plants					
Total number of species	48	60	45	93	–
Mean number of species	13.7 ± 2.8^{a}	15.5 ± 4.6^{a}	14.5 ± 5.7^{a}	21.5 ± 6.4^{b}	0.034
Species heterogeneity	34.3 ± 2.8^{a}	44.5 ± 4.6^{b}	30.4 ± 5.7^{a}	67.4 ± 6.4^{c}	0.0001
% Nitrophylous species	30.5 ± 10.6^{a}	38.9 ± 8.7^{a}	41.3 ± 8.8^{a}	10.7 ± 7.6^{b}	0.0001
Relative abundance of nitrophylous species	57.8 ± 35^{ab}	81 ± 21^{a}	48 ± 25^{b}	3.8 ± 7.3^{d}	0.0001

Table 3: Differences between young (BL_Y), intermediate (BL_A), mature (BL_M) black locust stands and the native forests stands (Benesperi et al., 2012).

While nitrophilous species constituted a large part of species richness and abundance in black locust stands, contribution and abundance of nitrophilous species in local stands were negligible.

As for the study by Aksoy et al. (2000), mean Pb, Cd, Zn and Cu concentrations (dry weight) in the leaves of *Robinia pseudoacacia* L. collected from different sites in the city of Kayseri. Leaves have been tested two separate ways as unwashed and washed. Concentrations of Pb, Cd, Zn and Cu in both unwashed and washed leaves was observed slightly higher in industrial sites. It has been concluded that higher concentrations of these heavy metals have been caused by Çukur plant. Density of traffic on the roadside and in urban areas is the main reason of high concentrations of heavy metals. See table 4.

	Pb			Cd		
Site	Unwashed	Washed	T-test	Unwashed	Washed	T-test
Industry	176.88 ± 12.2	62.42 ± 3.45	***	3.39 ± 0.14	1.22 ± 0.10	***
Roadside	74.46 ± 9.1	33.65 ± 3.30	***	1.34 ± 0.08	0.65 ± 0.08	***
Urban	48.96 ± 7.8	27.02 ± 3.01	***	1.12 ± 0.11	0.61 ± 0.08	***
Suburban	26.67 ± 6.2	21.04 ± 2.42	**	0.77 ± 0.07	0.58 ± 0.05	**
Rural	15.98 ± 1.9	14.89 ± 2.28	*	0.47 ± 0.05	0.44 ± 0.03	*
F- test	***	***		***	***	

	Zn			Cu		
Site	Unwashed	Washed	T-test	Unwashed	Washed	T-test
Industry	242 ± 11.10	98 ± 3.81	***	29.12 ± 2.54	14.04 ± 1.47	***
Roadside	80 ± 9.00	40 ± 2.76	***	22.98 ± 2.32	12.21 ± 1.32	***
Urban	67 ± 8.06	36 ± 2.75	***	18.56 ± 2.22	10.48 ± 1.14	***
Suburban	35 ± 5.08	26 ± 2.36	**	12.96 ± 1.30	8.96 ± 1.01	**
Rural	21 ± 1.66	19 ± 1.23	*	8 ± 1.11	7.32 ± 0.86	*
F- test	***	***		***	***	

Table 4: Mean Pb, Cd, Zn and Cu concentrations in the leaves of Robinia pseudoacacia L. (Aksoy et al., 2000).

It has been concluded due to high concentrations of Pb, Cu, Cd and Zn in the washed leaves the study of Aksoy et al. (2000), The results show that *Robinia pseudoacacia* L. can be useful as a biomonitor for the detection of heavy metal pollution in Turkey, Asia, Europe and Africa as well as in its native range United States of America.

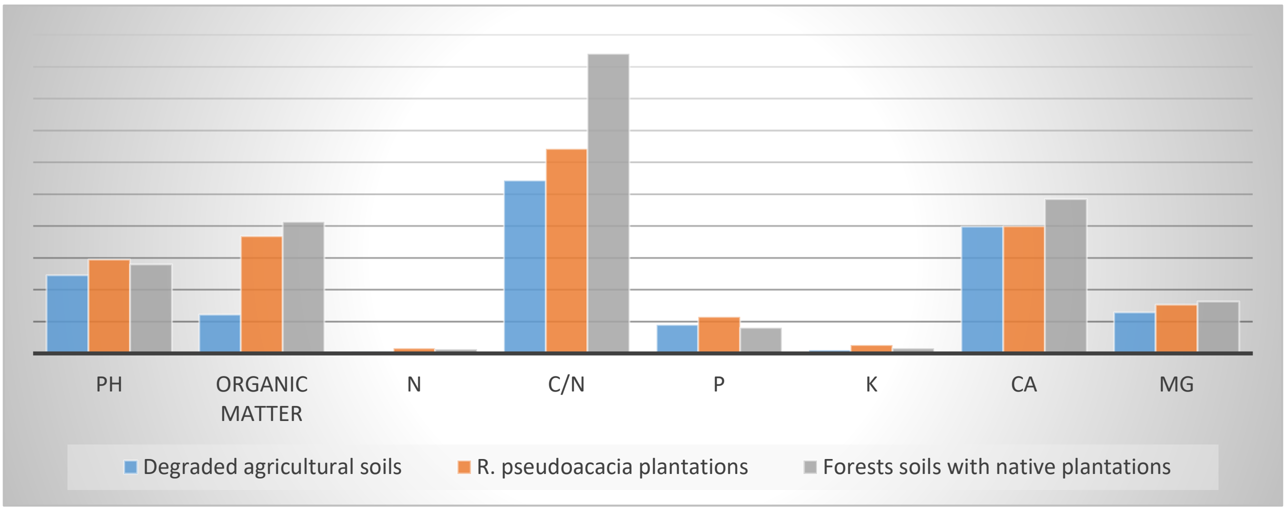

Figure 25: Concentrations of pH, organic matter and nutrient among three study area (Papaioannou et al., 2016; Modified).

As a result of the study that took place in Greece (Papaioannou et al., 2016), the lowest pH has been observed on degraded croplands. The results show that restoration on agricultural lands with *R. pseudoacacia* resulted in greater organic matter and soil nitrogen content, and significantly higher P and K concentrations when compared to the degraded agricultural lands. It has been concluded that due to high nutrient concentrations in black locust plantations were acceptable to optimum for plant growth.

4. CONCLUSIONS

Black locust is a challenging tree species. The tree has considerable economic potential: its wood has unique properties (especially durability and calorific value). If black locust is grown on a suitable site, this tree shows considerable wood production. Moreover, the tree can grow even in extreme locations (dry sandy soils and sand dunes, depleted soil substrates). Therefore, the nitrogen-fixing black locust may be used for site reclamation purposes under certain circumstances. It also provides significant non-wood production (e.g. nectar for bees, honey production).

On the other hand, black locust is highly competitive species with extreme invasive potential outside of the area of its natural distribution. Black locust may pose a serious threat for some valuable autochthonous habitats and native communities. *Robinia* is able to influence the soil environment through eutrophication and acidification. These undesirable ecological properties must in any case be taken into account when management of black locust is conducted.

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