EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology 2022, 23(2), 206–212
https://doi.org/10.12912/27197050/145612
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Received: 2021.12.15
Accepted: 2022.01.13
Published: 2022.02.01

Comparison of Growth Rate of Black Locust (*Robinia Pseudoacacia* L.) on Productive and Marginal Cultivated Lands for Sustainable Agroforestry Systems

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ABSTRACT

Robinia pseudoacacia is considered as a multipurpose tree because of its great adaptability to face environmental stresses and restore degraded sites, its valuable wood, easy propagation, excellent coppicing potential especially for high yield biomass production, high seedling survival etc. This tree represents an interesting perspective in ecological engineering, agroforestry and urban forest. For this reason, understanding its growth dynamics falls within the criteria of forest and peri-urban sustainability. The effects of soil condition on the survival and growth of *Robinia pseudoacacia* planted on degraded and cultivated land, respectively in Monte Romano site and Azienda Agraria didattico-sperimentale "Nello Lupori" site, in Italy, were studied in a field transplant experiment using the analysis of variance. Cultivated land showed higher survival rate because of the better soil, topography and climatic conditions. Height and diameter growth responded differently to soil conditions and monitoring period. Mean height and diameter increases were higher in cultivated land. A significant difference in height was found between the initial and final periods in cultivated land. This study is considered important because the selected species can help improving the soil conditions of the selected site so in the future this area can be reforested with valuable wood species. This has to be taken into consideration especially for Albania when illegal logging has created a strong decrease of forest surface associated with soil erosion phenomenon, overflooding, as well as overuse of the forest for firewood to fulfill the people demand, especially in rural areas. In addition, honey production is an important agroforestry aspect and the flowers of *Robinia pseudoacacia* are known for the production of good quality honey; moreover they can be used as medicinal plants.

Keywords: saplings, survival, height, diameter, initial period, final period.

INTRODUCTION

The agricultural land is used for growing food crops, especially those used for wood energy production (Rédei et al. 2011). The lack of highly productive native species with timber or growth characteristics suited to plantation forestry, force the use of exotic species such as black locust, as it can easily be established on certain sites, has better growth rates than native species, and possesses broader physiological adaptability with regard to site conditions (Keresztesi 1988; Rédei et al. 2008). Invasive alien species are species threatening biological diversity by occupying ecosystems outside of natural spreading areas. Among these invasive alien species that change the functions and natural components of ecosystems, especially the ones that are carried by seed and other plant material draw great attention (Beram et al. 2017).

Black locust (*Robinia pseudoacacia* L.) is considered a promising plantation species for the production of timber and biofuel, and its growth pattern has been analyzed in many countries (Keresztesi 1993). Due to its potential to produce large amounts of biomass yields even under unfavorable growth conditions, this tree species is especially suitable for marginal sites

(Böhm et al. 2011). Other important attributes of Black locust are its rapid growth and low concurrence rate by weeds. It is also highly resistant to fungi and pests, air pollution as well as low and high temperatures. Black locust is characterized by a vigorous sprouting of stump and root cuttings (Rédei et al. 2008, 2011). In particular, its root symbiosis with *Rhizonium* bacteria gives it a nitrogen fixing ability. Therefore, this species can help to improve the chemical properties and fertility of soil (Bolat et al. 2016; Papaioannou et al. 2016). On the other hand, this particular feature can cause an unwanted and long-lasting shift in vegetation composition toward nitrogen-rich and species-poor plant communities (Kowarik 2010).

According to this, the presence of this species should be carefully monitored around nature reserves and fragile landscapes in nutrient-poor and dry locations, as it has a great harmful potential (Enescu and Danescu 2013). Black locust is a multi-purpose crop, which can be grown for both quality timber and biomass, as well as for honey production. The cultivation to obtain high quality timber is possible only on the sites with adequate moisture and drainage conditions, whilst biomass production as both firewood or woodchips is allowed also on lower quality soils (Rédei et al. 2008, 2011).

Therefore, the main objective of this study was to compare the survival rate and growth of black locust saplings planted in two areas with different soil conditions, with particular reference in evaluating the possibility of cultivation on marginal lands. In the black locust energy stands established by coppicing, the quantity of biomass is lower and the length of rotation is highly influenced by the irregular diameter distribution (Re´dei et al. 2011). The cultivation of black locust into cultivated or degraded land could stimulate rural economies, counteracting the negative impacts of farm and land abandonment, or supporting the restoration of degraded land which results in improved biodiversity values.

MATERIALS AND METHODS

Study sites

There are nearly 377,186 ha of black locust in Italy (Monteverdi et al. 2016). The study area is located in the Viterbo region, composed by two sites. The first one, Azienda Agraria didattico-sperimentale "Nello Lupori", referred as cultivated land (hereafter abbreviated as site CL), and the second one, in Monte Romano municipality, referred as degraded cultivated land (hereafter abbreviated as site DL), both part of the Tuscia University (Table 1). These sites are located at a distance of 22.7 km from each other.

The sites have different elevations. The first site is located in a lower elevation than the second one with a difference of 50 m. Regarding the slope, the first site is located almost in a flat area whereas the second has a considerable slope percentage. Both areas face South-West. The temperatures are slightly higher in the second site, but this site is characterized by lower annual precipitations. Climatic and topographic description of the two sites can be found in following Table 1.

Experimental design

The "Nello Lupori" educational-experimental farm (CL) is located in Viterbo, in Riello area, 500 meters from the Department of Agriculture and it covers about 30 hectares. It is mainly used for agricultural and forestry experimental purposes. The soil is principally volcanic and only towards the coast is represented by clay deposits. This lithological formation, over time, has allowed the development in vast areas of the soil characteristics mostly brownish and rich in nutrients such as potassium oxide, phosphorus anhydride and calcium oxide. These soil characteristics enabled the use of this land for crops plantation year after year.

The Monte Romano experimental area (DL) has been used previously for agriculture but it was a non-profit area, therefore it became property of the Tuscia University for research purposes.

Table 1. Description of studied sites

Site	Latitude (N)	Longitude (E)	Elevation (m)	Slope (%)	Aspect	Mean annual temperature (ºC)	Total annual precipitation (mm)
CL	42°25'10"N	12°04'39"E	290	2.4	SW	14.4	726
DL	42°15'39"N	11°54'13"E	340	20.9	SW	15.1	680

Climatic data were obtained from https://it.climate-data.org

It has been cultivated several times with different exotic species, many of them not succeeded. The soil is flysch clayey with low permeability. The water flow is clearly influenced by runoffs that determine a strongly impulsive regime with flood episodes. The clay flysch marl soils are characterized by predominantly lower clayey portion, and in high calcareous and calcareous-marl-clayey soils with a lot of stones. In this context, the soils that are found, are rich in skeleton, with variable thicknesses according to the slope and consisting of alternations of thin horizons with more developed layers of brown calcareous type. The nutritive elements are quite scarce, especially the content of assimilable phosphorus anhydride is unsatisfactory. Moreover, they are poor in potassium oxide.

The *Robinia pseudoacacia* saplings, kindly granted by the nursery of C.F.S. of Pieve S. Stefano, were used in both plantation sites. They were all extracted at the same time, from the same area and they had the same age. The saplings were randomly selected when planted in both areas without any criteria about height and diameter. No previous interventions like plowing, fertilization, mechanic or chemical intervention for weeds control were made for terrain preparation. A manual drill was used to open the holes for sapling plantations. The plantation scheme used in both cases were 1x1 m. A total of 45 saplings were planted in the CL and 72 saplings in DL.

Measurements and statistical analysis

The saplings height and basal diameter were taken as baselines for determining the growth rate and were measured immediately after planting in mid-April 2007 (initial) and same measurements were repeated in July 2007, December 2007 and then first fortnight of December 2007 (final), in both areas in order to compare the growth between the plantation period and the end of growth one. Sapling death was also noticed.

G–test of independence was used to see whether the distribution of one variable at the initial phase and final phase are different in cultivated area and degraded cultivated area. In the same way, the same test was used to conclude about the distribution of each variable between both study areas in the initial and final phase. One-way analysis of variance (ANOVAs) procedures were used to compare the growth rate in height and diameter in cultivated land and degraded cultivated land.

Linear regression analysis of relationships between height and basal diameter of saplings planted on cultivated (CL) and degraded cultivated (DL) land was performed too.

RESULTS

Sapling survival at the end of growth period highly differed between sites. The highest mortality occurred at DL where 16 saplings died, whereas at CL only 3. The survival percentage of planted saplings was therefore 93% in CL and 78% DL. The distributions were compared among the two measurement periods using *G*-tests values and related significance levels (*P*).

The distribution of heights and diameters values in the initial period is characterized by an asymmetry to the lower heights in both the surfaces, while at the end of the period it follows the normal distribution (Fig. 1). There are statistically significant differences on both surfaces between the two periods, which is more pronounced in the case of cultivated land.

Heights and diameters distributions in the initial period resulted to be quite similar for both surfaces, while the final period was characterized by higher values on the cultivated surface (Fig. 2). Consequently, the comparisons between the distributions of heights and diameters reveal no significant changes in the initial period between the two surfaces, while in the final period, the differences are statistically significant for both variables taken into account.

Statistical parameters (*F*; *P*, significance level) comparing initial (dark grey box plots) and final (grey box plots) measuring period within sites are shown. Black horizontal line in box plots corresponds to mean values.

Mean height and diameter increases were highest for cultivated land and lowest for degraded cultivated land whereas height showed the highest percentage increase. There is a significant difference in height between initial and final period in cultivated land, while in degraded land there is no significant difference in height between two periods. Considering the diameter, the difference is significant in both ground typologies between both periods of cultivation. (Fig. 3).

There is no significant difference in height and diameter between cultivated land and degraded land in initial period, while the difference of this variables is significant in the final period between

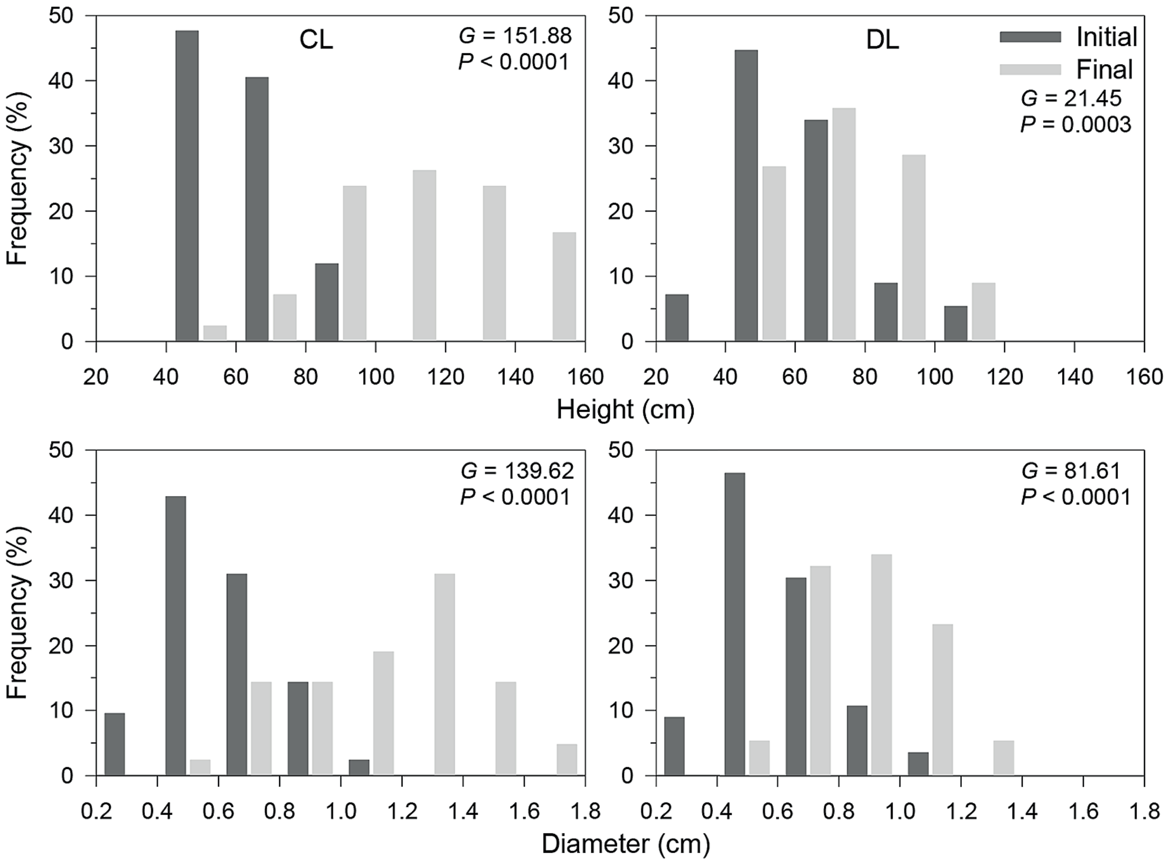

Figure 1. Distribution of height and diameter for each site

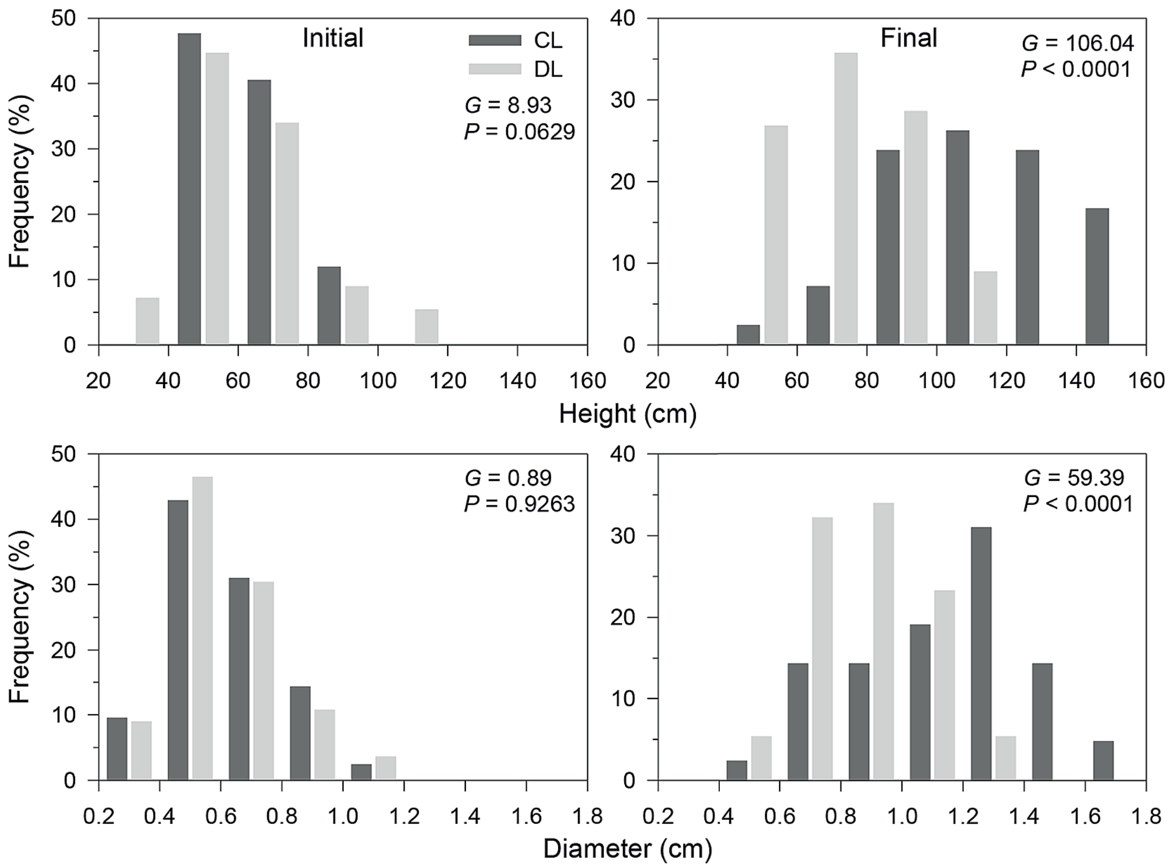

Figure 2. Distribution of height and diameter for each measurement period

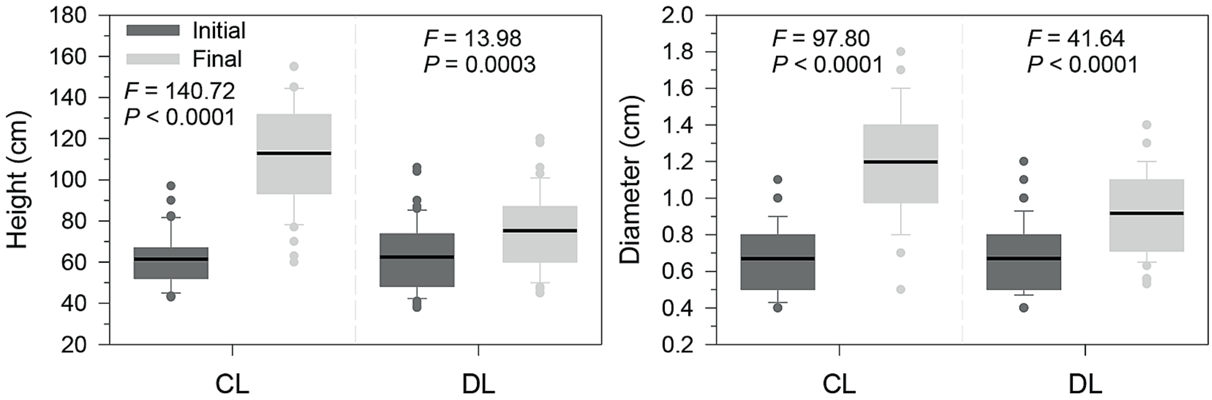

Figure 3. Variability of height and diameter for each studied site

both sites. The difference of increase and increase percentage for height and diameter is also significant between both ground typologies (Table 2).

Regression analysis revealed different relationships of height with diameter between cultivated and degraded cultivated land, showing stronger correlation at the degraded cultivated land at the initial period and at the cultivated land at the final period (Fig. 4).

DISCUSSION

Rédei et al. (2011) reports not to be reasonable with the plantation harvesting in the first three years, because the mean annual increment is higher with the passing of time.

According (Rédei et al. 2011) the height growth of black locust peaks within the first five years. The diameter growth in the first decade.

Table 2. Mean (± SE) values of height and diameter (at the initial and final measuring period as well as the increase between periods) for each site and their statistical parameters (*F*; *P*, significance level)

Parameters	Height				Diameter			
	Initial (cm)	Final (cm)	Increase (cm)	% Increase	Initial (cm)	Final (cm)	Increase (cm)	% Increase
CL	61.5 ± 1.94	112.9 ± 3.88	51.5 ± 3.41	87.2 ± 6.60	0.67 ± 0.03	1.20 ± 0.05	0.53 ± 0.04	84.6 ± 7.23
DL	62.5 ± 2.21	75.3 ± 2.61	12.8 ± 1.22	21.7 ± 2.39	0.67 ± 0.03	0.92 ± 0.03	0.25 ± 0.02	41.6 ± 4.41
F	0.1256	70.52	139.65	106.78	0.0003	29.02	52.01	28.37
P	0.7238	< 0.0001	< 0.0001	< 0.0001	0.9874	< 0.0001	< 0.0001	< 0.0001

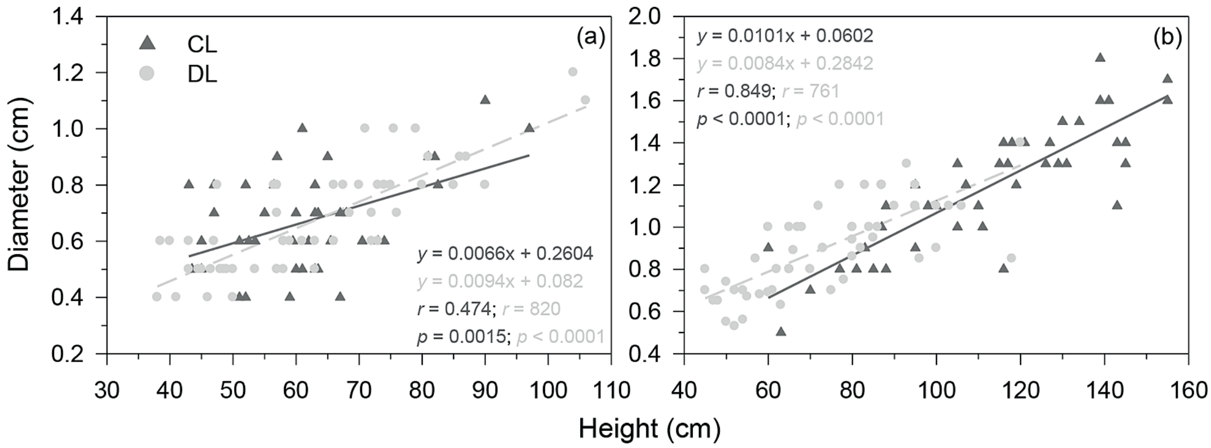

Figure 4. Relationships between height and basal diameter of the Robinia pseudoacacia saplings planted on cultivated (CL) and degraded cultivated (DL) land. The data represented in plot (a) were measured in mid-April 2007 (initial) and in plot (b) in first fortnight of December 2007 (final). Linear regression equation, correlation coefficient and the level of significance are shown for each case

On the other hand, in this study, the diameter increase percentage in cultivated land is lower than the height increase percentage in the same soil typology while the diameter increase percentage in degraded land is higher than the height increase percentage in the same soil typology. The results suggest that low soil quality can significantly impair the seedling growth on a degraded hillside.

Heights and diameters distributions in the initial period resulted to be quite similar for both surfaces considering the same provenience of seedlings from the nursery. The final period is characterized by higher values on the cultivated surface because of the adaption with the good terrain conditions. Regarding seedlings mortality, Rédei et al. (2011) reported a seedling mortality of about one-third at age 7 and 8. This percentage grows to nearly 50% while age passes to 12–13 years.

CONCLUSIONS

The higher seedling survival in cultivated land shows that soil conditions affect this characteristic. The majority of seedling mortality occurred in the dry season as a consequence of no post nursery care of planted seedlings. Precautions during seedling transportation and transplantation were effective in minimizing the transplantation loss. Height and diameter increase and increase percentage are higher in cultivated land then in degraded land indicating that soil conditions affect also this parameter. This study was limited, but early survival and growth are the keys to successful panorama of *Robinia pseudoacacia* uses in different sites.

Acknowledgements

We are grateful to Tuscia University for allowing us to conduct this field experiment on their lands. Thanks go to the nursery of C.F.S. of Pieve S. Stefano for saplings donation.

REFERENCES

1. Aravanopoulos F.A. 2010. Breeding of fast-growing forest tree species for biomass production in Greece. Biomass and Bioenergy, 34(11), 1531–1537.
2. Beram, et al. 2017. Dünya Çam Ormanlarını Tehdit Eden Yabancı İstilacı Tür; Fusarium circinatum. Bilge International Journal of Science and Technology Research, 1(1), 39-45.
3. Bolat I. et al. 2015. Influences of black locust (*Robinia pseudoacacia* L.) afforestation on soil microbial biomass and activity. iForest - Biogeosciences and Forestry, 9(1), 171–177.
4. Böhm C. et al. 2011. Yield prediction of young black locust (*Robinia pseudoacacia* L.) plantations for woody biomass production using allometric relations. Annals of Forest Research, 54(2), 215–227.
5. Enescu C.M., Danescu A. 2013. Black locust (*Robinia pseudoacacia* L.) - an invasive neophyte in the conventional land reclamation flora in Romania. Bulletin of the Transilvania University of Braşov, 6(55), 2.
6. Keresztesi B. 1993. Breeding and cultivation of black locust, *Robinia pseudoacacia*, in Hungary. Forest Ecology and Management, 6(3), 217–244.
7. Keresztesi B. 1988. The black locust. Akadémiai Kiadó, Budapest, 196.
8. Rédei, et al. 2008. Black locust (*Robinia pseudoacacia* L.) improvement in Hungary: A review. Acta Silvatica and Lignaria Hungarica, 4, 127–132.
9. Rédei, et al. 2011. Black locust (*Robinia pseudoacacia* L.) short-rotation crops under marginal site conditions. Acta Silvatica and Lignaria Hungarica, 7, 125–132.