STUDY ON THE EVOLUTION OF THE BLACK PINE STAND (*PINUS NIGRA*) ARTIFICIALLY INSTALLED ON THE SITE OF THE RECEA SUNCUIUS QUARRY, BIHOR COUNTY

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RESEARCH ARTICLE

Abstract
This paper presents the success of black pine plantations from 2008-2009 in the Recea Șuncuiuș Quarry, Bihor county. Thus, the degree of survival rate of the saplings planted 13 years ago was evaluated, measuring their diameters and heights by slope category. Six sample plots were selected for analysis. Tree diameters were found to be larger on medium slopes compared to flat and very steep plots. From a statistical point of view, the differences are only significant in terms of the measured heights, especially on the average slopes where they are different are different. Regarding the degree of survival of the seedlings planted, it recorded very good values. The research also highlights the advantages of black pine plantations, underlining the less demanding character of this species with respect to edaphic conditions. However, in the last 4 years, a degradation of artificially installed trees has been observed, especially in areas characterized by high atmospheric humidity.

Keywords: (afforestation, survival rate, saplings, clay quarry, medium diameter
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INTRODUCTION

The dominant genus in forest plantations is Pinus sp., constituting over 40% of global forest plantations (Brown, Ball 2007).

Black pine (*Pinus nigra* Arn.) is a Mediterranean species with several varieties. Its area reaches the south-western part of our country, where, on the Cernei Valley, the Banatian variety of more local forestry interest is spontaneously encountered. The Austrian black pine (P.nigra var. austriaca Hoss A. et G.) is the variety that has long prevailed throughout Europe for afforestation of degraded, dry and eroded, calcareous lands. In our country, it was used more for afforestation of degraded lands, especially in the south-western part of the country (Clinovschi, 2005).

Black pine stands are found at diverse altitudes, spanning from 350 m in Italy to 2,200 m in the Taurus Mountains, with the optimal altitudinal range falling between 800 to 1,500 m. This pine species displays adaptability to various soil types, ranging from podzolic sands to limestone, a characteristic often influenced by regional and climatic factors. Notably, the Austrian pine subspecies exhibits a higher tolerance for exposed chalk and limestone compared to the Corsican pine (Enescu et al., 2016).

The effectiveness and prosperity of forest plantations hinge on factors such as land suitability, meticulous site and species selection, proficient management, and silvicultural techniques. Indigenous to Europe and Asia, *Pinus* sp. spans from Spain and Morocco to Eastern Turkey, and from Cyprus to northeast Austria and the Crimea region in Russia, achieving a height of up to 50 m in its native habitats. Conifer plantations have shifted their primary objective from timber production to hydrogeological protection and forest restoration (Tavankar et al., 2018).

The wide ecological range of pine species, supported by their geographical distribution and ability to grow on land unsuitable for forest vegetation due to their superior production, has been widely recognized. These characteristics have promoted the use of pine species for afforestation or reforestation initiatives aimed at regenerating land affected by natural or anthropogenic degradation (Doniță et al., 2004; Silvestru-Grigore et al., 2018; Schulze et al., 2005).

Notably, during the 20th century, black pine was intentionally planted on eroded slopes and abandoned farmland, leading to the establishment of extensive black pine plantations, thereby contributing significantly to afforestation efforts (Mikulová et al., 2019).

The black pine, crucial for amelioration purposes in the Mediterranean karst region, holds exceptional value due to its diverse ecological and social roles, along with its commercial significance. As a key species for karst reforestation, it plays an irreplaceable role in preventing habitat degradation and erosion expansion. This has led to its widespread distribution across the entire Mediterranean, from the western to the eastern regions (Barcic et al., 2022). Quézel and Médail (2003) identify six subspecies of black pine in the Mediterranean. As the most widely distributed pine species in mountainous areas of the Mediterranean Basin, it is extensively utilized for afforestation. These pine forests, classified as "habitats of European interest," necessitate specific conservation measures outlined by the Convention for the Conservation of European Wildlife and Natural Habitats (Resolution 4/1996) due to challenges in achieving successful natural regeneration.

Using pine in the recovery of degraded land is limited to sheet erosion (Traci, 1985). The black pine proved to have sustained high growth even on highly eroded lands. Pines can offer good protection of the land and good yields: 3–8 m^3 yearly per hectare in forest steppe, 5–10 m^3 yearly per hectare in hill mixed hardwood area, 5–8 m^3 yearly per hectare in oaks and beech area, and 7–12 m^3 yearly per hectare in Norway spruce area, at the age of 30 years and on moderately pluvial eroded land (Traci, Untaru, 1986).

Plantation forests are pivotal in forest management, given their high productivity and significant contribution to carbon sequestration. Expanding the proportion of planted forests on non-forested lands worldwide has been proposed as an effective strategy to mitigate elevated concentrations of atmospheric carbon dioxide (Picchio et al., 2022; Doniță, Radu, 2013).

In addition to their pollution resistance, black pine forests exhibit a superior ability to absorb and accumulate heavy metals (Cr, Mn, Fe, Ni, Cu, Cd, and Pb) compared to other tree species (Katsidi et al., 2023).

In Romania, black pine plantations were created, especially in Transylvania. In general, the black pine was treated as a tree for green spaces, as well as for afforestation of degraded lands near cities and villages, on steep, rugged slopes, on degraded lakes, etc.

In this climatic context, it proves to be very undemanding, being able to grow on heavy clay soils, on steep calcareous slopes, exposed to excessive heating and dryness.

However, more than 100 Latin specific, varietal, and formal names have been recorded by different authorities and there is no general consensus (Enescu et al., 2016).

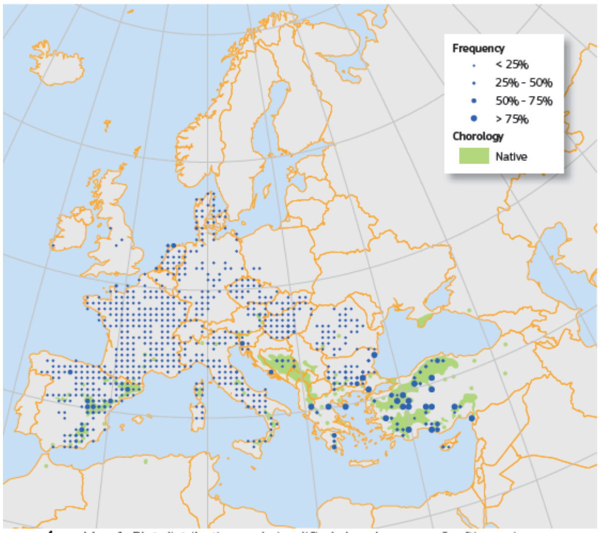

Figure 1 **Plot distribution and simplified chorology map for *Pinus nigra*.** Frequency of *Pinus nigra* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for P. nigra is derived after EUFORGEN (quoted by Enescu et al., 2016)

The main purpose of this work is to analyze the diameter and height of black pine trees after 13 years of planting in tje Recea Suncuius Quarry, depending on the slope. Of course, there are other factors that influence these characteristics, such as: soil, temperature, precipitation, exposure, altitude, provenance, damage caused by animals (Boja et al., 2016) etc.

MATERIAL AND METHOD

The Şuncuiuş refractory clay deposit is located in the northern part of the Pădurea Craiului Mountains, on the territory of the Şuncuiuş commune, Bihor county. The exploitation perimeter is made up of two sectors: the Recea sector with an area of 2.89 km^2 and the Balnaca sector with an area of 0.75 km^2.

Access to the Recea sector is via a concrete industrial road, which goes up from the village of Şuncuiuş towards the former

Recea mining sector, the Cornu mine and the Recea Quarry.

The altitudes of the area are between 300 m - Valea Crişului Repede and 837 m - Vârful Cărmăzan.

In 2008-2009 Scots pine *Pinus sylvestris* L. and black pine *Pinus nigra* J. F. Arnold seedlings were planted, which had better success. Research and measurements were carried out between December 2022 and January 2023, in the perimeter of the 2008 Cold Quarry Dump (figure 2, 3), near the towns of Șuncuiuș and Zece Hotare, from Șuncuiuș commune, Bihor county, in the northern part of the Pădurea Craiului Mountains.

In 2008-2009, black pine saplings were planted on Halda 2008 and on the plateau, which proved to be quite a good option because they took hold in a good proportion (up to 90%), problems existing only in locations with excess moisture and low slope.

The planting scheme was 2x2m.

The factor analyzed in this paper was the slope, denoted by:

- P1 the test surfaces located on the slope $<5^{o}$;
- P2 the test surfaces located on the slope between 5^{o} and 15^{o};
- P3 the test surfaces located on the slope $>15^{o}$.

For each slope category (variant P1, P2, P3) 2 repetitions (S1-S2) were placed, resulting in six sample plots, 10m x 10m, located according to figure no. 3.

In each sample plot, the entire trees were inventoried and measurements of the following characteristics were performed:

- the survival rate of saplings at the age of 13-14 years, expressed in number of specimens and %;
- the height of the saplings (m) from the ground level to the top of the axis or to the highest point of a frame;
- the diameter of the seedlings in the package (cm);
- other observations: the number of vertices, edaphic observations, the number of branches in the first 30 cm from the ground, other naturally installed species and the number of specimens.

The diameter was measured with the electronic caliper (fig. 4a), and the height with the Vertex 5 device (fig. 4b).

Table 1

Location and elevation of sample plots

Slope, in degrees	Sample Plot Code	Coordinates, (Latitude Longitude)	Altitude, in meters
P_1 $\leq 5^{o}$	S_1P_1	46°55'16.2"N 22°30'43.8"E	689
	S_2P_1	46°55'16.7"N 22°30'43.8"E	685
P_2 $(5^{o} - 15^{o})$	S_1P_2	46°55'16.7"N 22°30'43.0"E	687
	S_2P_2	46°55'16.1"N 22°30'42.9"E	691
P_3 $\geq 15^{o}$	S_1P_3	46°55'14.3"N 22°30'43.1"E	698
	S_2P_3	46°55'14.7"N 22°30'42.7"E	692

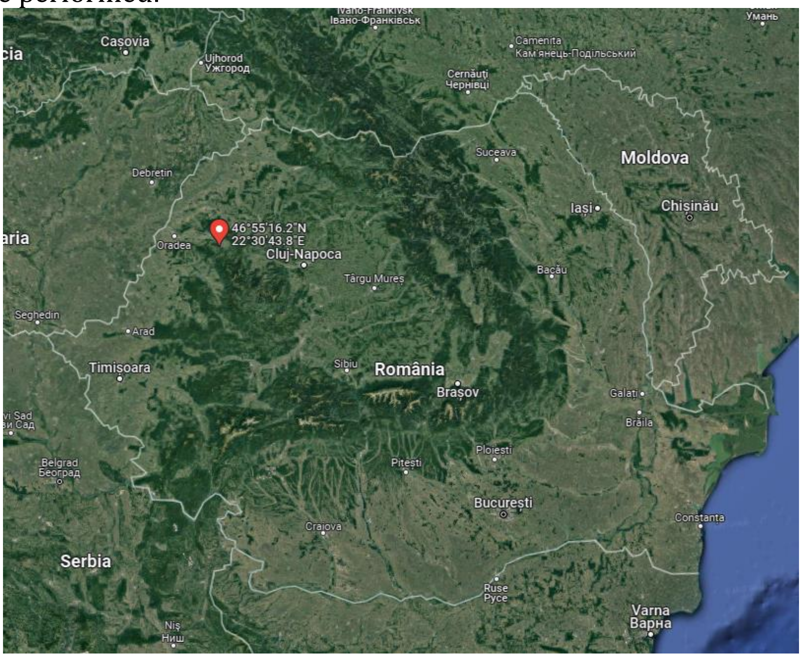

Figure 2 **Geographical position of the Suncuius Quarry**
(https://www.google.com/maps/@46.891636,22.5527247,8561m/data=!3m1!1e3?entry=ttu**)**

Figure 3 **Location of the study and sample plots** (https://maps.app.goo.gl/cwR2YcdxjzaxPDBs7)

a b

Figure 4 **Diameter measurement with a caliper (a) and of the tree height with Haglöf Vertex 5 Hypsometer (b)**

For the analyzed characters (survival rate, plant height, diameter in the package) the arithmetic mean was determined using the well-known formula x = Σx/N.
To determine the survival rate after 13 years, the following formula was used:

$$G_m(\%) = \frac{P_{viab}}{P_{veg}} \cdot 100$$

in which: P_{veg} represents planted seedlings (50 pcs);
P_{viab} - existing seedlings after 13 years.

The outcomes derived from biometric assessments on the specified traits underwent statistical analysis using variance analysis, employing the monofactorial experiments conducted in randomized blocks. The significance of distinctions between the two tested varieties was determined through the LD test and the "t" test (Student), as outlined by Ardelean et al. (2002).

RESULTS AND DISCUSSIONS

Regarding the survival rate after 13-14 years after the planting of the black pine saplings under study, the data of table 2 show the fact that out of 25 saplings planted in 2008-2009 per 100m^2, they are found in the spring of 2023 only 18 pcs. in sample plot S1P1 and S1P2 (the fewest) and 24 specimens in S1P3 (the most). Thus, the survival rate is located between 72% and 96%, well above the acacias planted 7 years ago in the same area (Bodea et al., 2022).

Table 2
The number of plants and the survival rate after 14 years after planting, in %

Slope	The number of plants and the survival rate for …	
	S1	S2
P1	18/72	21/84
P2	18/72	22/88
P3	24/96	21/84

According to figure 5, it can be seen that the survival rate of the planted saplings increases polynomially with the slope of the land, registering a percentage of 90% for lands with a steep slope of over 15^{o}.

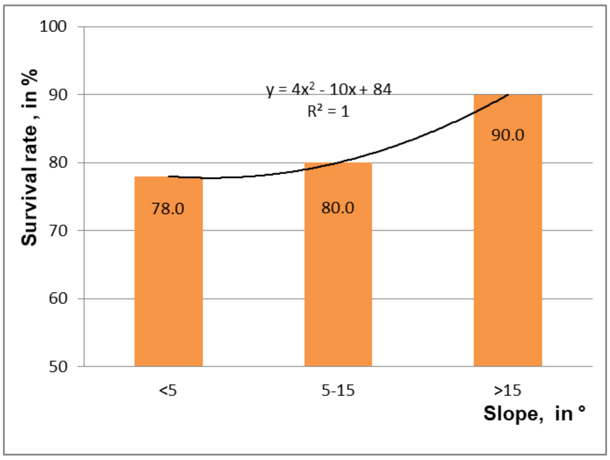

Figure 5 **Representation of the means of the four repetitions in terms of the survival rate of the planted seedlings**

It is observed that the survival rate of seedlings varied between 78% and 90%, which represents very good results.

Regarding the average diameter of the package, the measured values are centralized in table 3. For the six analyzed surfaces, the average diameters were between:

- for S1P1: 4.4-12.5 cm, with a coefficient of variability of this character of 27.41%, which places the variability of that character in the "large" class;
- for S1P2: 5.0-12.30cm, s%= 25.16%) which falls into the "large" class of variability;
- for S1P3: 4.80-15.00cm, s%= 61.60%, which falls into the "very high" class of variability.

Table 3

Values of average diameters measured (d_m) after 13 years from planting

The variant, (categories of slope)	d_m for the plot…, in cm	
	S1	S2
P1	7.24	8.78
P2	8.50	8.17
P3	8.29	8.28

It can be observed that for all 3 categories of slope, there is a large and very large variability in terms of the dimensions of the parcel diameter, expressed by the values of the coefficients of variability.

Table 4 shows the summary results regarding the differences between the average diameters at the parcel and in table 6 the differences between the average heights of the saplings after 13 years from planting according to the 3 categories of slope on which they were planted, as well as the interpretation of these results separately for each slope category.

Table 4

Effects of the land slope on the mean root neck diameter of trees after 13 years of vegetation

The name of variant	Mean root neck Ø, in cm	% versus P1	±d, in cm	Significance of difference
P1 - martor	8.01	100.0	-	-
P2	8.33	104.0	0.32	-
P3	8.28	103.4	0.27	-
DL/LSD 5 % =			1.7	
DL/LSD 1 % =			2.6	
DL/LSD 0.1 % =			2.8	

Thus, although the parcel diameter values remain higher by 4% in option 2 (slope 5-15°) compared to those recorded in var. 1 and by 3.4% compared to variant 3, from the point of view of statistical assurance the differences between the three variants are insignificant.

Regarding the average height, the measured values are centralized in table 5. For the first 3 analyzed surfaces, the amplitude of variation (A) for the heights was:

- for S1P1: A=3.4m, with a coefficient of variability of this character of 21.56%, which places the variability of that character in the "large" class;
- for S1P2: A=3.0m, s%= 15.39%, which falls into the "high" class of variability;
- for S1P3: A=3.8m, s%= 58.91%) which falls into the "very high" class of variability.

It can be observed that for all 3 categories of slope, there is a large and very large variability in terms of the value of the tree heights, expressed by the values of the coefficients of variability.

Table 5

Values of average heights measured (hm) after 13 years from planting

The variant, (categories of slope)	h_m for the plot…, in cm	
	S1	S2
P1	4,15	4,99
P2	5,29	5,75
P3	4,68	4,79

On the low slope, a high branching tendency was observed, with 23.1% of the trees measured showing this defect. On the medium slope P2, 15% of the measured trees had branching, and on the slope P3>15° only 2 trees showed branching, representing 4.4%.

Figure 6 shows that 54% of the landslides were found on low-slope terrain.

Table 6

Effect of the land slope on the tree heights after 13 years of vegetation

The variant	Mean root neck Ø, in cm	% versus P1	±h, in m	Significance of difference
P1 - blank test	4.57	100.00	-	-
P2	5.52	120.88	0.95	**
P3	4.73	103.61	0.16	-
DL/LSD 5 % =			0.6	
DL/LSD 1 % =			0.9	
DL/LSD 0.1 % =			2.5	

Thus, from the point of view of statistical assurance, the tree height values for option 2 (slope 5-15°) are distinctly significant compared to those recorded at variant 1, and the differences between P1 and P3 are insignificant.

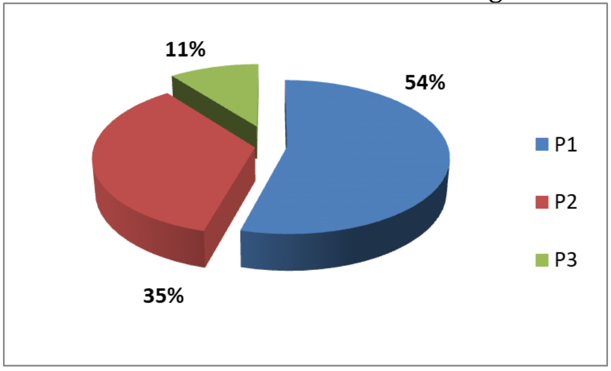

Figure 6 **Distribution of branched trees by slope categories**

CONCLUSIONS

Following the statistical analysis, it was found that the slope does not significantly influence the survival rate of the black pine saplings or the diameter after 13 years after planting.

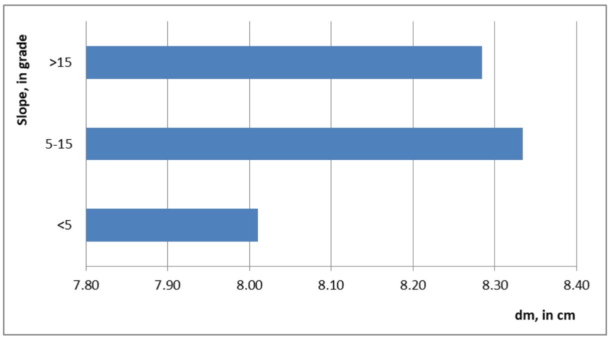

Figure 7 **Representation of average diameters by slope categories**

Regarding the height of the saplings, it is observed that on a medium slope (5-15°) the heights of the saplings are distinctly significantly higher than on a low slope.

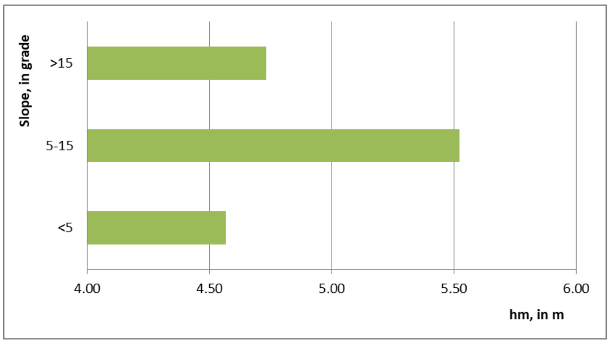

Figure 8 **Representation of average heights by slope categories**

The degree of seedling retention increases with the slope, there being a positive correlation, so that on a slope above 15°, the number of seedlings that survived was 90% of the total planted.

It is essential to plant areas that have not regenerated naturally, especially considering that a significant proportion of these lands are on very steep slopes and are exposed to erosion phenomena. The results were good even on very steep slopes as was the case with the S1P3 test surface, where the slope exceeded 25°. Here you can see a lot of erosion and a lot of rock on the surface.

The black pine tree planted on the tailings dump from the Recea quarry in 2009 presented a relatively good state of health in the first 10 years after installation. In the last 4 years, however, there have been attacks on the foliar apparatus by the fungi responsible for successive diseases, which in order of frequency are as follows: *Laphodermium pinastri, Dothistroma pini, Sphaeropsis sapinea, Cyclaneusma minus.* The peak of the attack of these foliar pathogens was in 2022 characterized by a very dry summer, followed by a rainy autumn, favoring the development and propagation of these complex pine diseases (figures 9).

The strongest attacks were recorded in the test areas located on land with a slope of more than 10o, with sunny exposure, at the top of the slopes, where there is an excess of heat and a deficit of moisture. In the trees located in these locations, the degree of damage to the leaf apparatus is 30-40% (figures 10), and in some specimens it exceeds 50% in the lower third of the crown.

Figure 9 **Attacks of the foliar apparatus by the fungi responsible for successional diseases**

Figure 10 **Trees with an increased degree of damage to the leaf system**

From the analysis of the biometric data measured in the six sample plots, it follows that the average value of the diameters and heights is lower in the heavily affected surfaces.

Successive diseases or complex diseases were observed in some of the trees, and many pathogens act together and destroy the trees: Dothistroma, Lophodermium, Sphaeropsis, Cyclaneusma, etc.

In conclusion, these complex diseases can lead to the decline of the pine trees on the tailings dump at Quarry Recea, the limiting factors being drought and the reduced amount of nutrients in the soil. Another negative consequence of the attack of foliar fungi on pines is the reduction of their ability to carry out photosynthesis, which implies lower resources in the supply of nutrients, followed by reduced growth and a decrease in immunity to stress factors.

Dominant tree species that naturally regenerate on the tailings dump include birch, Scots pine, quaking poplar, buck willow, acacia, wood apple, and wild hair. In terms of shrubs, mulberry, rosehip, hawthorn and common juniper occur naturally.

For example, on the small slope, in the S1P1 sample plot, naturally settled: 1 willow, 1 Scots pine, 5 blackberries, 1 hawthorn, 3 planted acacias, 4 birches, 2 quaking poplars, and in S2P1: 1 willow, 3 planted acacias, 6 birches, 1 aspen.

On the high slope, over 15^{o}, we do not have natural shrubs and trees installed.

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