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Current dendrometric characteristics of the spruce (*Picea abies*) installed in the "Şuior amelioration perimeter", Baia Sprie Forest Division, Maramureş Forestry Division, 20 years after planting

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Abstract. The measurement of the dendrometric characteristics concerning the growth and development of forest vegetation on exhausted lands - refuse heaps in the "Şuior amelioration perimeter" allows us to use the information obtained from measurements carried out in other such badlands in the entire county or country. One of the tree species used in this amelioration perimeter was the spruce (*Picea abies*), which presented extraordinary results in respect of its development.
Key words: Spruce, root collar diameter, station type, correlation analysis.

Introduction. Forest vegetation, installed on such exhausted lands, has an important role not only in the conservation and protection of the soil against erosion, but also in its ongoing amelioration. The contribution of forest vegetation consists in the amelioration of both physical and chemical properties of the soil. The soil's physical properties grow worse especially when it is sunk by animals, in case of grazing and by heavy machineries regardless of their use. Soil loosening is carried out by the subsequent development of the roots of ligneous plants and by the activation of the organisms in the soil, which are found in a much larger number in forest soils (Traci 1985).

The Şuior amelioration perimeter has a total surface of 24.00 ha (Leşan 2009, 2012) and only a surface of 15.60 ha was afforested in 1990 with black fir, spruce, birch, mountain ash and white alder seedlings. According to the nature of degradation, the surface was divided as follows: 2.30 ha with strong-excessive surface erosion, 3.30 ha deep erosion (gullies, bevels and ravines) and 10.00 ha non-consolidated deposits.

The purpose of this article is to highlight the dendrometric characteristics of the spruce after 20 years from plantation, so that this information can be used for the afforestation of other surfaces with such species.

Material and Method. In order to determine the dendrometric characteristics of the installed spruce, the tracking and control of regenerations was carried out in compliance with the "Technical norms for the annual control of regenerations", approved by Order no. 1653 from 31.10.2000 of the Ministry of Water, Forests and Environment Protection (MWFEP).

Control surfaces placed and delimited in a specific manner have been used for collecting data from the field (Rob 2011). In the regenerations carried out on the entire surface of the study unit, regardless of the means through which these were obtained (natural, mixed or artificial) control surfaces were used, which in total represent:
- 8% of the surface of the culture under control, for surfaces less than 5 ha;
- 4% of the surface of the culture under control, for surfaces between 5 and 10 ha.

The shape of these control surfaces is regular (circle). The dimensions of such a surface differ according to the terrain's inclination and the size of the regenerated surface under control (Table 1).

Table 1

Calculation of testing sectors in the Şuior amelioration perimeter (Leşan 2003)

No.	*Study unit*	*Total surface (ha)*	*Artificial regeneration (ha)*	*Natural regeneration (ha)*	*Total control surfaces (%)*	*Test surface size (mp)*	*Number of required sectors*
1	1	2.00	1.90	0.10	8	100	16
2	2	2.90	2.00	0.90	8	100	23
3	3	0.76	0.38	0.38	8	100	6
4	4	0.50	0.05	0.45	8	100	4
5	5	1.16	1.16	0.00	8	100	9
6	6	5.16	4.15	1.01	4	200	10
7	7	0.88	0.32	0.56	8	100	7
8	8	1.85	1.57	0.28	8	100	15
9	9	1.06	0.10	0.96	8	100	8
10	39N1	7.73	3.97	3.76	4	200	15
Total		24.00	15.60	8.40	-	-	-

Depending on the surface of regeneration, the following control surface dimensions were used: 100 m^2 for regeneration surfaces under 3 ha and 200 m^2 for regeneration surfaces above 3 ha.

The practical placement in the field was carried out using an imaginary rectangular network. The network was established in relation to the first control surface which was set in a corner of the regenerated surface.

As an in-the-field working method (Bîrda & Leşan 2010):

- all the present and viable seedlings were counted in each testing sector, out of which those which grew to heights of 1.30 m were counted separately;
- the following characteristic was measured for each seedling: root collar diameter (of each present and viable seedling), the diameter at 1.30 m for those taller than 1.30 m and the height of each present and viable seedling);
- the distance between whorls, tracking the annual growth and the length of the biggest branch, in order to determine the drip-line projection.

As an office-working method (Leşan 2012):

- the arithmetic mean of the three dendrometric characteristics was calculated for each sector, determining the average diameter per root collar, the average diameter at 1.30 m and the average height;
- knowing the station type on which each testing sector is situated (Table 2), the arithmetic mean of the measured dendrometric characteristics could partially be calculated according to station types and species, thus being able to correlate the data obtained through regression equations.

Table 2

Distribution of testing surfaces on station types within the Şuior amelioration perimeter

U.S.	*Number of testing surface*	*Station type*
1	P1-P4	RFa4
	P5	AFa5
	P6-P8	Hmc1
	P9-P16	EFa11
2	P1,2,4-6,10,11,13,16,18,19	Hmc1
	P3,7-9,12,14,15,17	Hmc1u
	P20-P23	4430
3	P1-6	4430
4	P1-4	4430
5	P1-9	Hmc1t
6	P1-9	Hmc1l
	P10	4430
7	P1-7	4430
8	P1-11	Hmc1lt
9	P1-15	4430
39N1	P1-10	Hmc1
	P11-15	Hmc1t

From the total of the analysed surfaces, the most are situated on stations the soils of which are antropically degraded. Namely, Hmc1 (Traci 1985) - mining heaps consisting of mainly coarse rock materials (boulders, stones, gravel, with no or few coarse of fine materials), consisting of acid and neutral rocks, in stations from mountain areas, from the beech and spruce sub-regions, which in the current context also has four types of sub-types: Hmc1l - includes the mining heap deposits, consisting of neutral and acid rock fragments, which are easily resoluble and alterable, with a soil skeleton content between 70-90%, with a 5

degree inclination; Hmc1l - includes in addition temporary water surplus in micro-depressions and phreatic moist regions; Hmc1t - includes bevels for mining heap deposits, from neutral and acid rock fragments, which are easily resoluble and alterable, with a soil skeleton content between 70-90%, with a 15-50 degree inclination, lined by trickles and gullies and Hmc1tl - includes bevels for mining heap deposits, from neutral and acid rock fragments, which are easily resoluble and alterable, with a soil skeleton content between 70-95%, with a 25-40 degree inclination, lined by trickles and gullies.

Another type of station is EFa11, with a very strong degree of erosion, with inclinations >15 degree, lithologic sublayer consisting of hard, acid and intermediary rocks, with outbursts at the surface of the land, the soil thickness being between 21 and 50 cm, with textures from sandy to sand clay, with a high soil skeleton content (between 26-75%), oligotrophic. The surface covered by this type of station is 1.10 ha, which include slopes with an inclination of 30-45 degrees, very strong and excessively weatherworn.

The RFa4 station type represents a type of station with soil degraded due to deep erosion caused by water, consisting of gullies with a lithological sublayer made of crumbly and/or slightly consolidated rocks, with banks in the rock, loose at the surface at a small depth of 5-20 cm, with a soil skeleton content of 0-50%, with instable terrain. The surface occupied by this type of station is 0.19 ha, which locally presents an inclination of 35-50 degrees.

The least represented station type is AFa5, which consists of exhausted land due to alluviation (torrential drift deposits), more exactly blocks (deposits of boulders and stones with some gravel and sand), in which the sand proportion is under 25%, with accessibility for ligneous plants to ground water and water from the stream. The surface amounts to 0.1 ha, representing alluviation deposits in the alluvium of the hydro-technical works and ravine bottoms consisting mainly of rock fragments with gravel and sand.

Results and Discussion. In the Şuior amelioration perimeter (Leşan & Bîrda 2012), in the 113 testing sections positioned throughout the entire studied terrain, 2089 viable spruce seedlings have been identified (Table 3), out of which 731 had heights over 1.30 m.

Table 3

Mean results of the characteristics measured (root collar diameter and height) in the Şuior amelioration perimeter

Seedling no.	*Spruce (Picea abies)*		
c.d.>1.30m	*Diameter at 1.30 (cm)*	*Collar diameter (cm)*	*Height (cm)*
2089 (100%)	-	6.18	279.99
731 (34,99%)	5.75	9.16	-

Starting from the basic data which have been drafted for each unit of study individually and later distributed into the existing station types (Table 4), the study will continue with the correlation of the root collar diameters with the heights, distinctively on the most representative types of stations, tracking the differentiation of the spruce's development on each station type of found exhausted land.

Table 4

Distribution of all the catalogued seedlings and of those with heights over 1.30 m according to station types in the Şuior amelioration perimeter

No. of seedlings	*RFa4*		*AFa5*		*Hmc1*		*EFa11*		*4430*		*Hmc1u*		*Hmc1t*		*Hmc1tI*		*Total*	
	%	*No.s.*	*%*	*No.s.*	*%*	*No.s.*	*%*	*No.s.*	*%*	*No.s.*	*%*	*No.s.*	*%*	*No.s.*	*%*	*No.s.*	*%*	*No.s.*
Total seedlings	100	15	100	1	100	706	100	94	100	207	100	220	100	561	100	285	100.00	2089
d.c.>1.3m	40	6	100	1	29	204	38	36	65	134	34	74	14	76	70	200	34.99	731

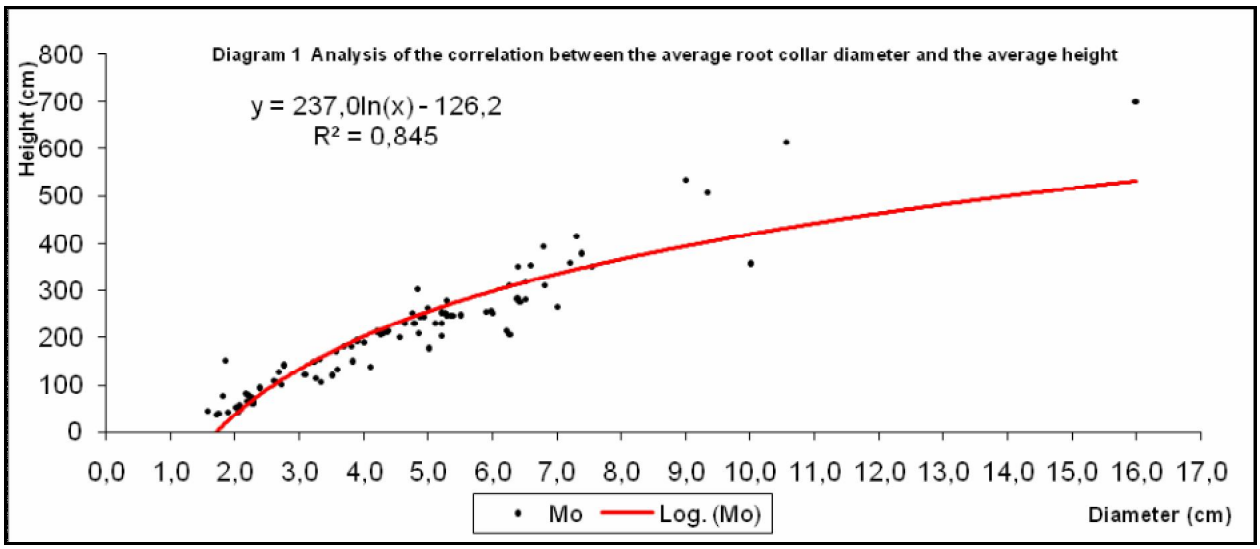

Figure 1. Correlation between average root collar diameter and average height.

Considering the data from each station type, results the previous diagram (Figure 1) which indicates a strong correlation between the spruce diameter and height values in the entire Şuior amelioration perimeter. The correlation coefficient r=0.92 indicates a strong correlation between the two variables, which suggests that the spruce experiences a generally constant development throughout the entire amelioration perimeter.

In the first station type, where the data concerning the growth and development of spruce is significant (Hmc1), the correlation coefficient r=0.88 suggests a close relation between diameter and height (Figure 2).

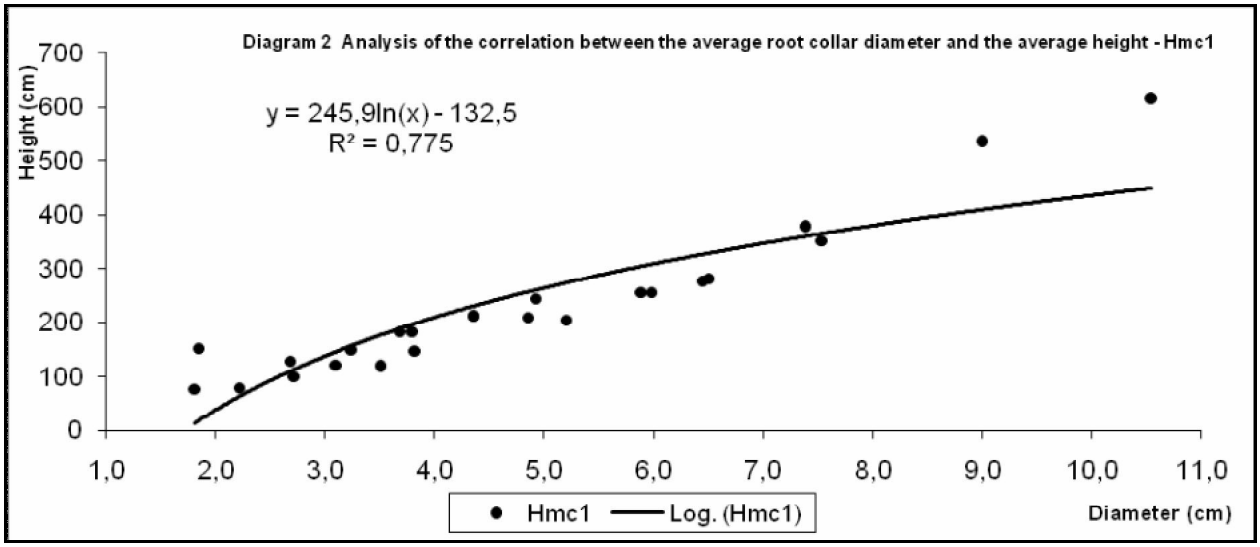

Figure 2. Correlation between average root collar diameter and average height - Hmc1.

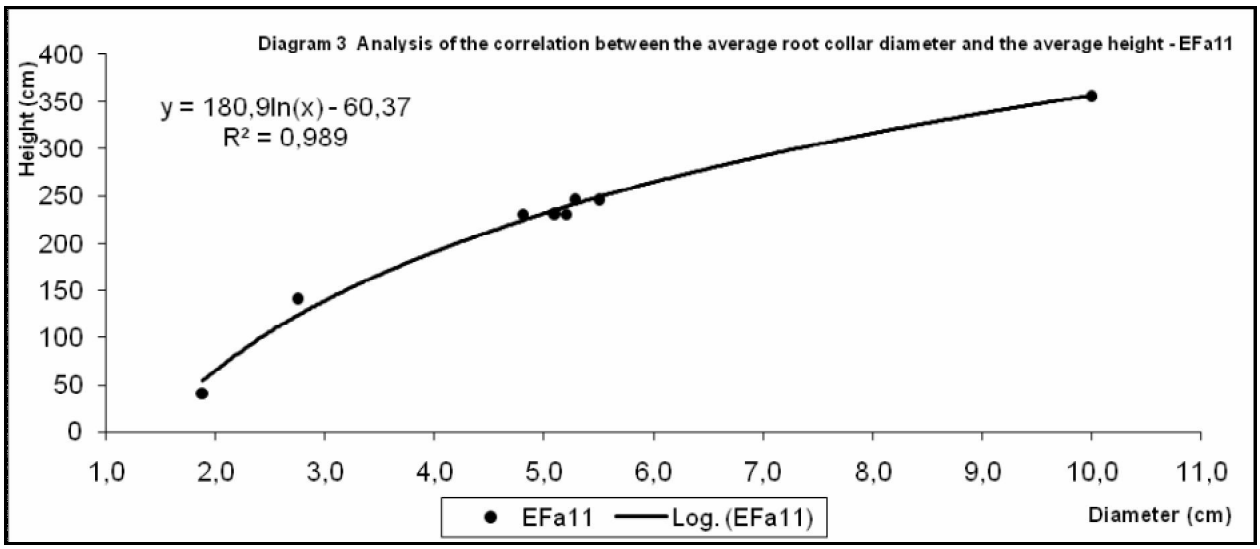

Figure 3. Correlation between average root collar diameter and average height – Efa11.

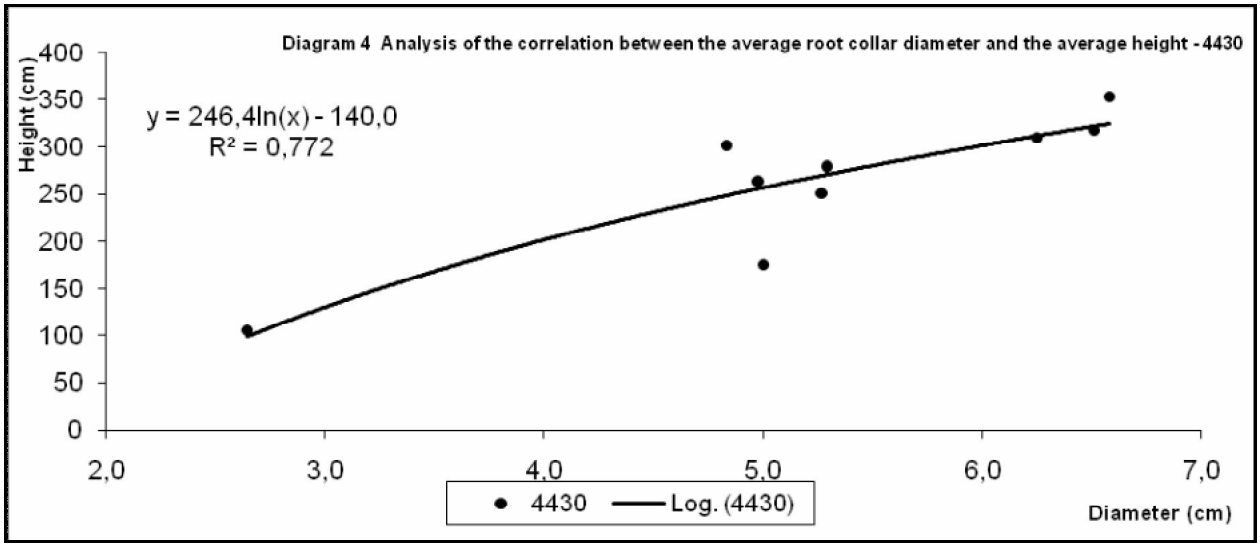

Figure 4. Correlation between average root collar diameter and average height – 4430.

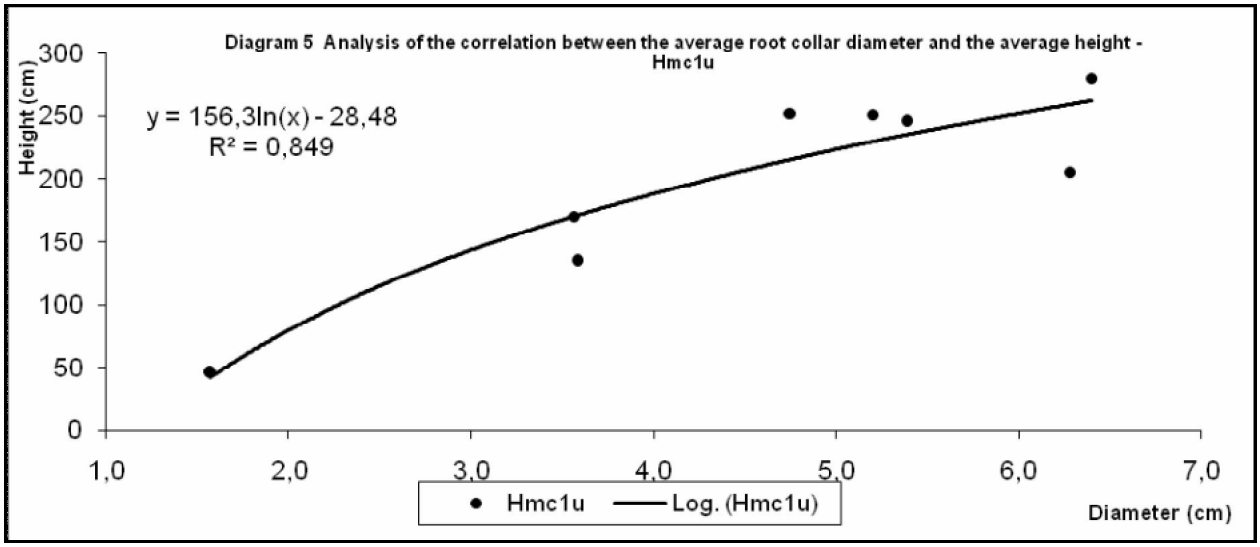

Figure 5. Correlation between average root collar diameter and average height – Hmc1u.

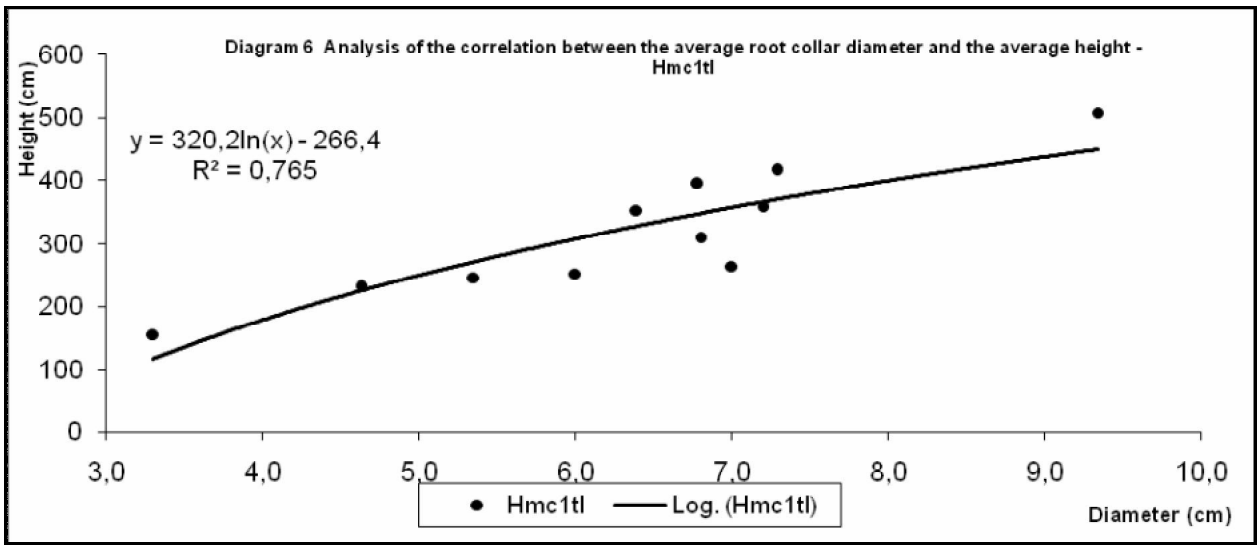

Figure 6. Correlation between average root collar diameter and average height – Hmc1tl.

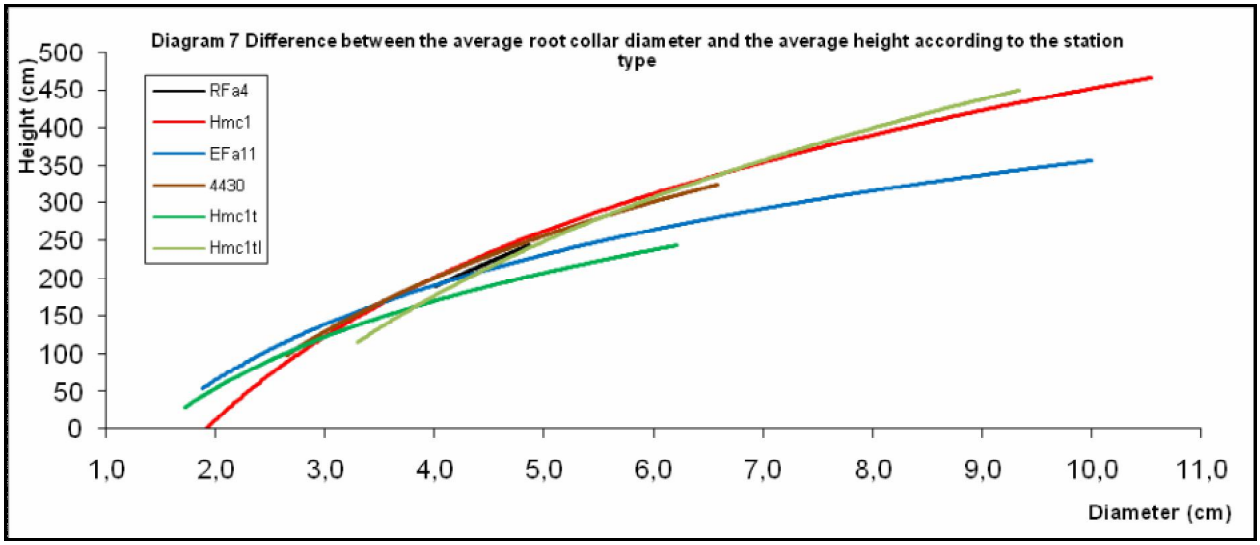

Figure 7. Difference between average root collar diameter and average height according to the station.

The diagrams referring to the analysis of the correlations between average spruce diameters and heights, obtained in the station types, which are the most representative from a statistical point of view, found in the Şuior amelioration perimeter (Figures 2-6) generally indicate a strong correlation between the two studied variables, with a general correlation coefficient r=0.92.

On each station type, which is statistically representative, the highest correlation coefficient (r=0.99) is found on the station type EFa11 and the lowest (r=0.87) on the station type Hmc1tI.

However, by comparing the correlation curves obtained on each station type individually (Figure 7), it can be observed that the best growths recorded by the spruce, both in diameter and height, were on the station type Hmc1 and the lowest on Hmc1t.

In order to determine, as accurately as possible, the growth and development of forest vegetation on these types of terrains, in the case of spruce seedlings other dendrometric characteristics have also been measured, such as: the drip-line and the growth in height in the previous 5 years (length between whorls).

These measurements corroborated with the root collar diameter of the catalogued species allowed the centralization of data on diameter categories (of 1.50 cm each), the cumulation of the number of seedlings for these categories, the average calculation of drip-line according to diameter categories (depending on the measured radius of the circle which forms the drip-line) and the mean diameters between whorls, V1 representing the last annual growth and V5 the growth 5 years ago, all divided according to the station types of exhausted lands.

Table 5

Results of the measures dendrometric characteristics (drip-line and growth in the last 5 years) in the Şuior amelioration perimeter

Root collar diameter category (cm)	*No. of seedlings*	*Projection (cm^2)*	*V1 (cm)*	*V2 (cm)*	*V3 (cm)*	*V4 (cm)*	*V5 (cm)*
				RFa4			
3.50-5.00	15	12805	14.50	14.80	9.20	10.15	11.30
Total RFa4	15	-	-	-	-	-	-
				AFa5			
15.50-17.00	1	138474	102	95	92	85	62
Total AFa5	1	-	-	-	-	-	-
				Hmc1			
0.50-2.00	59	10125	5.20	5.80	6.90	8.10	7.50
2.00-3.50	212	12024	9.50	7.50	8.90	11.80	11.20
3.50-5.00	222	15078	15.60	18.80	12.50	17.40	13.50
5.00-6.50	127	28086	29.50	21.40	21.50	19.80	17.50
6.50-8.00	48	32056	24.00	26.40	24.20	23.50	18.50
8.00-9.50	18	35201	25.10	24.80	28.40	23.50	26.50
9.50-11.00	20	38568	26.80	24.70	29.40	30.50	18.90
Total Hmc1	706	-	-	-	-	-	-
				EFa11			
0.50-2.00	28	8147	5.20	2.80	4.10	5.10	8.70
2.00-3.50	2	9868	7.59	6.87	7.82	11.48	10.25
3.50-5.00	10	17405	12.80	15.84	10.54	15.40	15.40
5.00-6.50	49	21325	28.40	26.70	24.10	27.50	28.40
9.50-11.00	5	31412	32.50	34.10	32.80	28.50	36.40
Total EFa11	94	-	-	-	-	-	-
				4430			
2.00-3.50	28	10145	8.05	6.51	8.21	11.15	9.85
3.50-5.00	63	13561	14.20	10.80	11.58	13.40	11.50
5.00-6.50	63	25325	25.00	20.50	16.80	18.80	14.40
6.50-8.00	53	29396	25.00	24.50	24.50	21.40	22.40
Total 4430	207	-	-	-	-	-	-
				Hmc1u			
0.50-2.00	7	8145	4.86	4.84	6.35	7.58	5.89
3.50-5.00	79	14250	14.70	15.20	10.50	13.28	13.40
5.00-6.50	134	21451	24.50	19.80	24.20	23.80	26.30
Total Hmc1u	220	-	-	-	-	-	-
				Hmc1t			
0.50-2.00	98	8114	4.82	4.90	6.50	7.50	5.70
2.00-3.50	256	10125	7.80	6.15	7.80	10.10	10.50
3.50-5.00	187	13504	13.50	14.25	9.10	13.40	11.80
5.00-6.50	20	20451	24.50	21.40	23.80	24.50	25.40
Total Hmc1t	561	-	-	-	-	-	-

Root collar diameter category (cm)	*No. of seedlings*	*Projection (cm^2)*	*V1 (cm)*	*V2 (cm)*	*V3 (cm)*	*V4 (cm)*	*V5 (cm)*
				Hmc1tI			
2.00-3.50	25	11451	8.50	7.80	8.40	11.50	10.90
3.50-5.00	12	17485	15.10	15.80	10.80	14.70	13.50
5.00-6.50	126	28974	24.50	28.70	19.80	20.50	21.70
6.50-8.00	100	31524	28.40	24.50	27.80	21.40	22.50
9.50-11.00	22	60154	35.20	32.10	28.70	26.80	24.80
Total Hmc1tI	285	-	-	-	-	-	-
Total spruce seedlings Şuior	2089	-	-	-	-	-	-

The spruce exhibited diameters between 0.5 cm and 11.0 cm (with an average of all the catalogued seedlings of 6.18 cm - Table 5), with extreme values in the upper part of 17 cm.

According to the station type, the spruce exhibits the following characteristics:

*RFa4 – 15 catalogued seedlings, diameters between 3.5 cm and 5.00 cm, drip-line projection of 12805 cm^2 (average radius of the circle describing the crown's projection of 63.86 cm), with annual growths not exceeding 14.50 cm;

*Hmc1 – 706 catalogued seedlings, diameters between 0.50 cm and 11.00 cm, drip-line projection from 10125 cm^2 (average radius of the circle describing the crown's projection of 56.78 cm) for the category 0.50-2.00 cm, up to 38568 cm^2 (average radius of the circle describing the crown's projection of 110.83 cm) with annual growths from 5.20 cm up to 29.50 cm in the last year and from 7.50 cm up to 26.50 cm annual growth from 5 years ago.

*EFa11 – 94 catalogued seedlings, diameters between 0.50 cm and 11.00 cm, drip-line projection from 8147 cm^2 (average radius of the circle describing the crown's projection of 50.94 cm) for the category 0.50-2.00 cm, up to 31412 cm^2 (average radius of the circle describing the crown's projection of 100.02 cm) with annual growths de la 5.20 cm up to 32.50 cm in the last year and from 8.70 cm la 36.40 cm annual growth from 5 years ago.

*4430 – 207 catalogued seedlings, diameters between 2.00 cm and 8.00 cm, drip-line projection from 10145 cm^2 (average radius of the circle describing the crown's projection of 56.84 cm) for the category 2.00-3.50 cm, up to 29396 cm^2 (average radius of the circle describing the crown's projection of 96.76 cm) with annual growths de la 8.05 cm up to 25.00 cm in the last year and from 9.85 cm la 22.00 cm annual growth from 5 years ago.

*Hmc1u – 220 catalogued seedlings, diameters between 0.50 cm and 6.50 cm, drip-line projection from 8145 cm^2 (average radius of the circle describing the crown's projection of 50.93 cm) for the category 0.50-2.00 cm, up to 21451 cm^2 (average radius of the circle describing the crown's projection of 82.65 cm) with annual growths de la 4.86 cm up to 24.50 cm in the last year and from 5.89 cm la 26.30 cm annual growth from 5 years ago.

*Hmc1t – 561 catalogued seedlings, diameters between 0.50 cm and 6.50 cm, drip-line projection from 8114 cm^2 (average radius of the circle describing the crown's projection of 50.83 cm) for the category 0.50-2.00 cm, up to 20451 cm^2 (average radius of the circle describing the crown's projection of 80.70 cm) with annual growths de la 4.82 cm up to 24.50 cm in the last year and from 5.70 cm la 25.40 cm annual growth from 5 years ago.

*Hmc1tI – 285 catalogued seedlings, diameters between 2.00 cm and 3.50 cm, drip-line projection from 11451 cm^2 (average radius of the circle describing the crown's projection of 60.39 cm) for the category 2.00-3.50 cm, up to 60154 cm^2 (average radius of the circle describing the crown's projection of 138.41 cm) with annual growths from 8.50 cm up to 35.20 cm in the last year and from 10.90 cm up to 24.80 cm annual growth from 5 years ago.

From the point of view of these measured characteristics, we may observe that the spruce has developed the largest crown (the largest surface of drip-line projection) and the greatest annual growth (V1, V2, V3, V4 and V5) in the station types Hmc1tI and Hmc1, values which are in direct correlation with the also superior root collar diameter and height values obtained by the spruce on these station types.

Conclusions. There is a strong correlation (r=0.91) between the overall root collar diameter and height. In general, the spruce developed in a relatively uniform manner, however it developed in the best manner on station type Hmc1 - mining heap deposits, made of neutral and acid rock fragments, which are easily resoluble and alterable, with a soil skeleton content between 50-70%, with mixes micro-relief, with under 15 degree inclination. Total number of catalogued seedlings 2.089, out of which 731 have experienced height growths over 1.30 m (34.99%); the highest percentage achieved from this point of view is on the station type Hmc1tI - bevels for mining heap deposits, from neutral and acid rock fragments, which are easily resoluble and alterable, with a soil skeleton content between 70-95%, with a 25-40 degree inclination, lined by trickles and gullies from the sub-region of beech and conifers. The greatest projection of the drip-line was exhibited on the station type Hmc1tI, but also on Hmc1.

All the previous data allow us to conclude that the spruce may be used successfully on such types of exhausted terrains, too.

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