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Development stage of the spruce (*Picea abies*) installed in the "Valea Dochii amelioration perimeter", Baia Sprie Forest Division, Maramureş Forestry Division, 10 years after planting

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Abstract. The development state of forest species on exhausted lands - refuse heaps in the "Valea Dochii amelioration perimeter" allows us to use the information obtained from measurements in other such badlands in the entire county or country. One of the forest species used in this amelioration perimeter was the spruce (Picea abies), which presented extraordinary results in respect of its development.
Key Words: spruce, station type, correlation analysis, root collar diameter.

Introduction. The Valea Dochii amelioration perimeter has a total surface of 22.90 ha (Leşan 2009, 2012a, 2012b), from which 5.57 ha remained in the use of the Şuior mine, 1.41 ha are covered and consolidated with forest vegetation, only a surface of 15.92 ha being afforested in the year 2000 with black fir, spruce, birch, mountain ash and white alder seedlings (Leşan & Bîrda 2012). According to the nature of degradation, the surface was divided as follows (Traci 1985): 7.84 ha 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 (granite, syenite, dacite, rhyolite, andesite, various fine crystalline slates, freestone, etc.), in stations from mountain areas, from the beech and spruce sub-regions, being classified as mining heap platforms from the sub-mountain - mountain region, beech sub-region, consisting of acid rocks, generally with coarse texture (Hmc1a); 7.04 ha 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 (granite, syenite, dacite, rhyolite, andesite, various fine crystalline slates, freestone, etc.), in stations from mountain areas, from the beech and spruce sub-regions, being classified as instable heap banks, with surface erosion and trickles, from the sub-mountain - mountain region, beech sub-region, consisting of acid rocks, generally with coarse texture (Hmc1b); 0.63 ha 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 (granite, syenite, dacite, rhyolite, andesite, various fine crystalline slates, freestone, etc.), in stations from mountain areas, from the beech and spruce sub-regions, being classified as highly instable heap banks with ravines and trickles, with over 35 degree slopes, from the sub-mountain - mountain region, beech sub-region, consisting of acid rocks, generally with coarse texture (Hmc1c) and 0.41 ha - swamp (IIIA3).

The purpose of this article is to highlight the dendrometric characteristics of the spruce after 10 years from planting, so that this information can be used for the afforestation of other surfaces with such species (Bîrda & Leşan 2010).

Material and Method. The analysis of the development stage of the spruce was carried out by tracking and controlling regenerations, "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.

In the Valea Dochii amelioration perimeter, the surface of the culture which is being controlled is assimilated with the study unit (Rob 2011), considering its entire surface, not only that which is afforested. In the 21 study units from the Valea Dochii amelioration perimeter, 134 testing sectors (Table 1) have been carried out.

Table 1

Calculation of testing sectors in the Valea Dochii amelioration perimeter

Study unit	*Total surface (ha)*	*Artificial regeneration (ha)*	*Natural regeneration (ha)*	*Number of required sectors*
1	1.95	1.95		15
2	1.05	1.05		8
3	0.70	0.70		5
4	0.41	0.41		3
5	0.96	0.96		8
6	1.37	1.12	0.25	11
7	1.53	1.53		12
8	0.55	0.30	0.25	4
9	0.86	0.86		7
10	0.55	0.55		4
11	0.45	0.45		3
12	0.34	0.34		3
13	0.13	0.13		Integral
14	0.18	0.18		Integral
15	0.42	0.42		3
16	1.17	0.41	0.76	9
17	0.19	0.19		Integral
18	0.74	0.59	0.15	6
19	0.78	0.78		6
20	1.90	1.90		15
21	1.10	1.10		9
Total	17.33	15.92	1.41	

Control surfaces placed and delimited in a specific manner (Leşan 2003) have been used for collecting data from the field. 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% from the surface of the culture under control, for surfaces under 5 ha.

The shape of these control surfaces is regular (circle), the size of each sector being 100 m^2. 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:

- 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 1.3 m for those taller than 1.30 m and the height (of each present and viable seedling);
- the distance between the verticels, tracking the annual growth and the length of the biggest branch, in order to determine the drip-line projection.

As an office-working method:

- 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 offering the possibility to correlate the data obtained through regression equations.

Table 2

Distribution of testing sectors on station types within the Valea Dochii amelioration perimeter

Study unit	*Number of testing sector*	*Station type*
1	P1,6,7,11	Hmc1b1
	P2,3,8,12	Hmc1b2
	P4,5,9,10,13-15	Hmc1a
2	P1,4,5,8	Hmc1a
	P2,3	Hmc1b2
	P6	Hmc1b1
3	P1-4	Hmc1a
	P5	Hmc1b1
4	P1-3	IIIA3
5	P1-4,7	Hmc1a
	P5,6	Hmc1b1
	P8	Hmc1b2
6	P1,4	Hmc1c
	P2,3,5,9-11	Hmc1a
	P6,8	4430
	P7	Hmc1b1
7	P1	Hmc1b2
	P2-4,7-12	Hmc1a
	P5,6	Hmc1b1
8	P1-4	Hmc1b2
9	P1-3	Hmc1b1
	P4-7	Hmc1a
10	P1-4	Hmc1b2
11	P1-3	Hmc1b2
12	P1-3	Hmc1c
13	Integral	Hmc1b2
14	Integral	Hmc1c
15	P1	Hmc1b1
	P2,3	Hmc1a
16	P1-3	Hmc1b2
	P4-9	4430
17	Integral	Hmc1a
18	P1,6	Hmc1a
	P2,3	Hmc1b1
	P4,5	4430
19	P1-3	Hmc1a
	P4,5	Hmc1b1
	P6	Hmc1b2
20	P1,2	Hmc1b1
	P3-15	Hmc1a
21	P1-9	Hmc1b2

The station types found in this amelioration perimeter are: Hmc1-a - mining heap platforms from the sub-mountain - mountain region, beech sub-region, consisting of acid

rocks, generally with coarse texture, with grass patches and spruce specimens; on the other hand, this type of station occupies the largest surface from the entire amelioration perimeter with 7.84 ha (49.24%) from 15.92 ha; Hmc1-b1 - stable heap banks, with slopes under 20°, from the sub-mountain - mountain region, beech sub-region, consisting of acid rocks, generally with coarse texture, with grass patches and spruce specimens on 3.02 ha (18.97%) from 15.92 ha; Hmc1-b2 - instable heap banks, with 20-35° slopes, with surface erosions and trickles, from the sub-mountain - mountain region, beech sub-region, consisting of acid rocks, generally with coarse texture, on 4.02 ha from the entire surface; Hmc1-c - highly instable heap banks with ravines and trickles, with slopes over 35°, from the sub-mountain - mountain region, beech sub-region, consisting of acid rocks, generally with coarse texture, 0.63 ha and IIIA3 - swamps with surplus rain water from the mountain area, beech sub-region, with hygrophilous vegetation (*Juncus, Phragmites*) and isolated goat willows covering a surface of 0.41 ha.

Results and Discussion. In the Valea Dochii amelioration perimeter, in the 134 testing sections positioned throughout the entire studied surface, 1031 viable spruce seedlings have been identified (Table 3), out of which 691 with heights over 1.30 m.

Table 3

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

Seedling no.	*Spruce (Picea abies)*		
c.d.>1.30m	*Diameter at 1.30 (cm)*	*Collar diameter (cm)*	*Height (cm)*
1031 (100%)		5.06	296.64
691 (67.02%)	5.56	8.26	

Starting from the basic data which has 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 existing 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 Valea Dochii amelioration perimeter

No. of seedlings	Hmc1a		Hmc1b1		Hmc1b2		Hmc1c		4430		Total	
	%	No. s.	%	No. s.	%	No. s.	%	No. s.	%	No. s.	%	No. s.
Total seedlings	100	435	100	178	100	233	100	45	100	140	100,00	1031
d.c.>1.3m	65	283	81	145	71	166	71	32	46	65	67,02	691

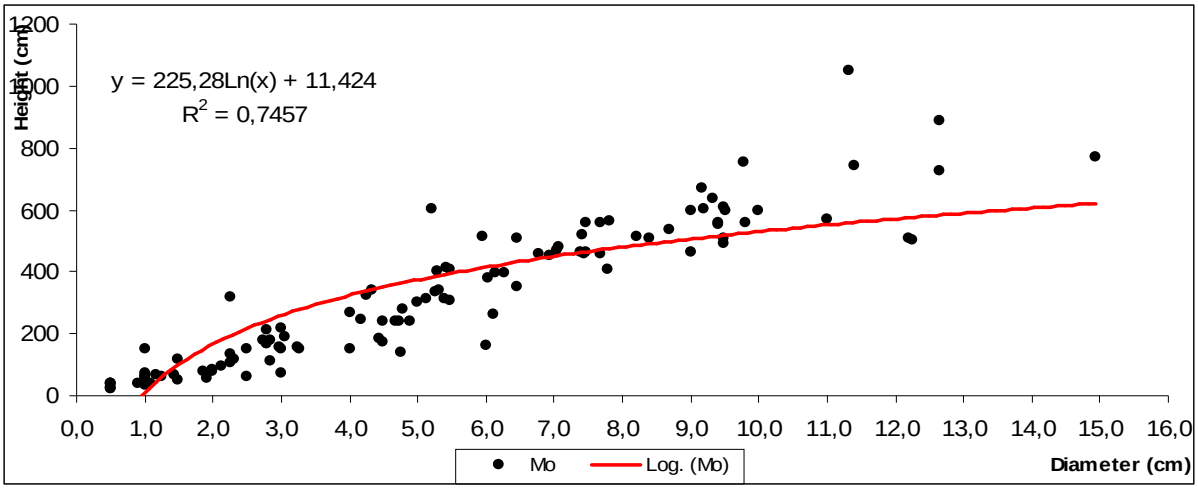

Figure 1. Analysis of the correlation between the average root collar diameter and the average height.

Considering the data from each station type, results the previous diagram (diagram 1) which indicates a strong correlation between the spruce diameter and height values (r=0.86) and this shows us that the spruce has experienced a very good development in the Valea Dochii amelioration perimeter, too.

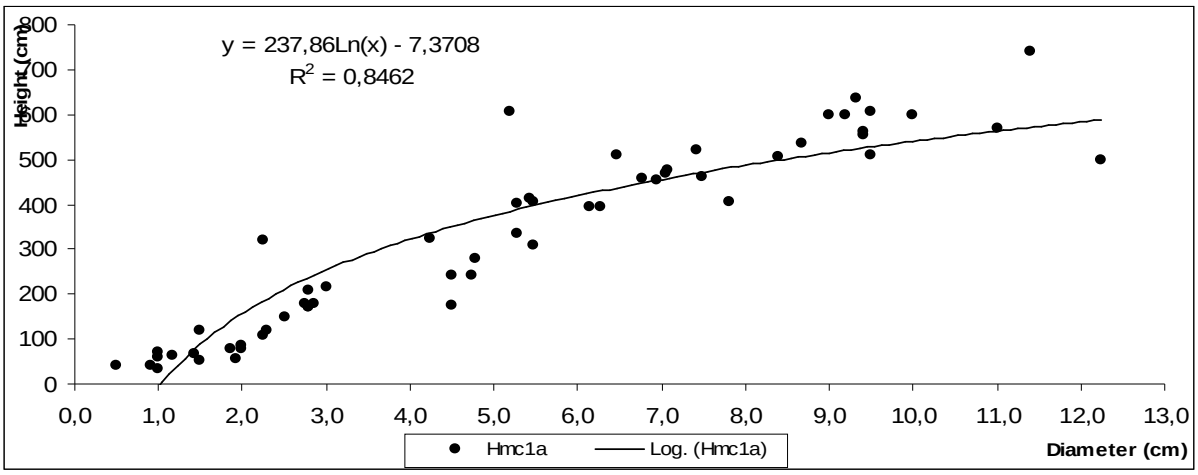

Figure 2. Analysis of the correlation between the average root collar diameter and the average height – Hmc1a.

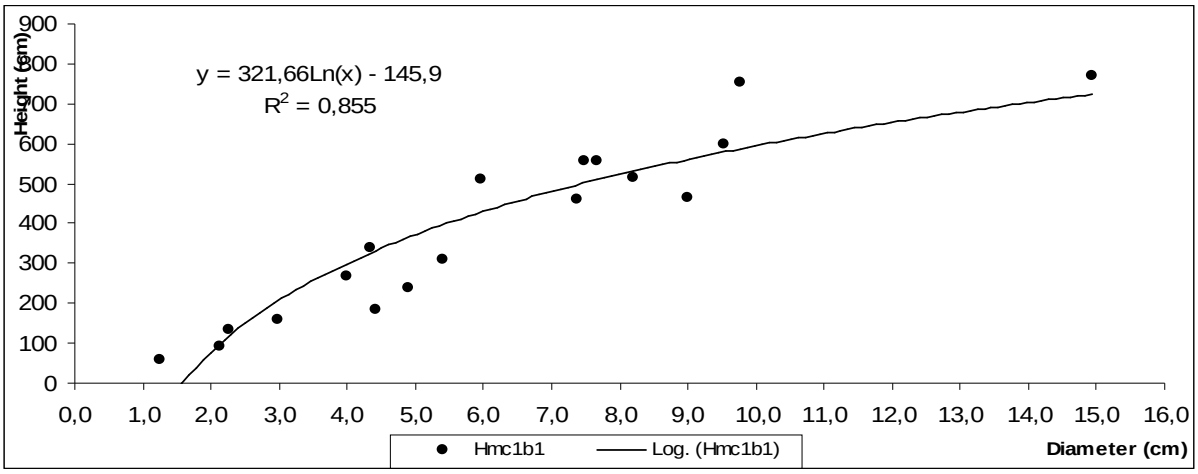

Figure 3. Analysis of the correlation between the average root collar diameter and the average height – Hmc1b1.

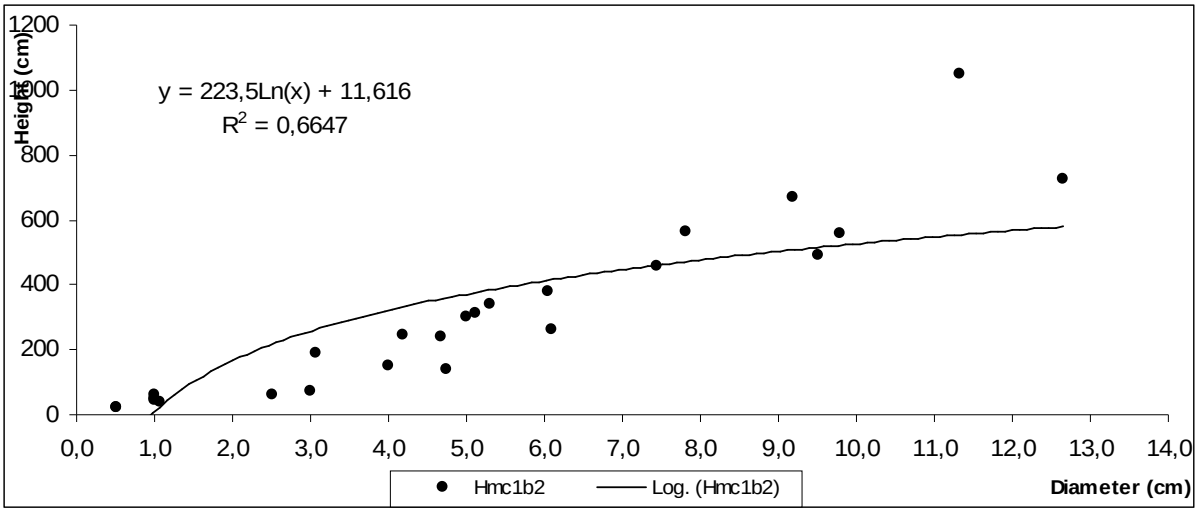

Figure 4. Analysis of the correlation between the average root collar diameter and the average height – Hmc1b2.

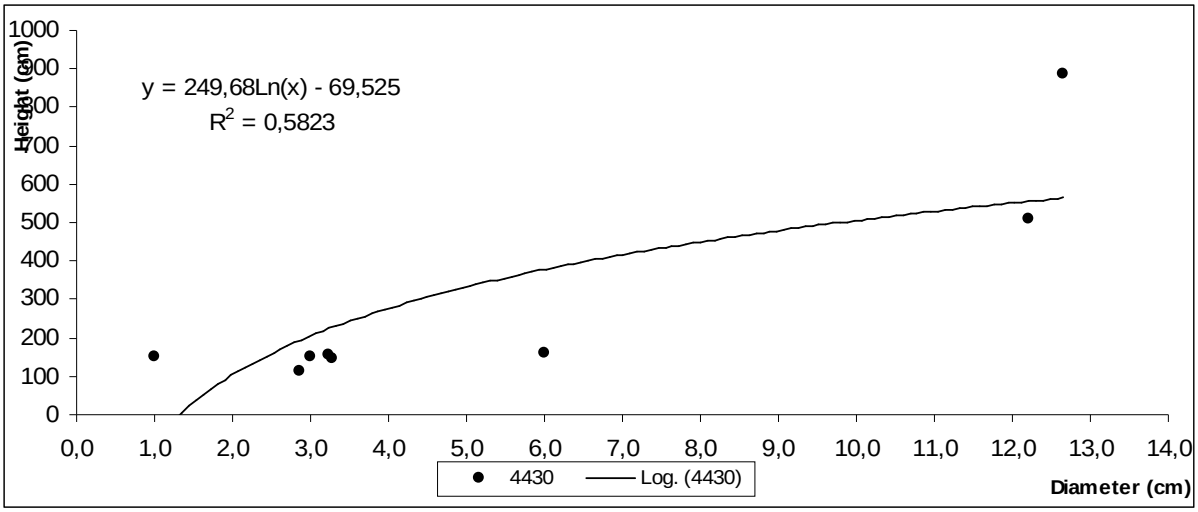

Figure 5. Analysis of the correlation between the average root collar diameter and the average height – 4430.

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 Valea Dochii amelioration perimeter (Figures 2-6) generally indicate a strong connection (r=0.86). By comparing the correlation curves obtained for each station type (Figure 6), we can notice that the spruce has recorded generally constant growth on all station types, with the best development on Hmc1b1.

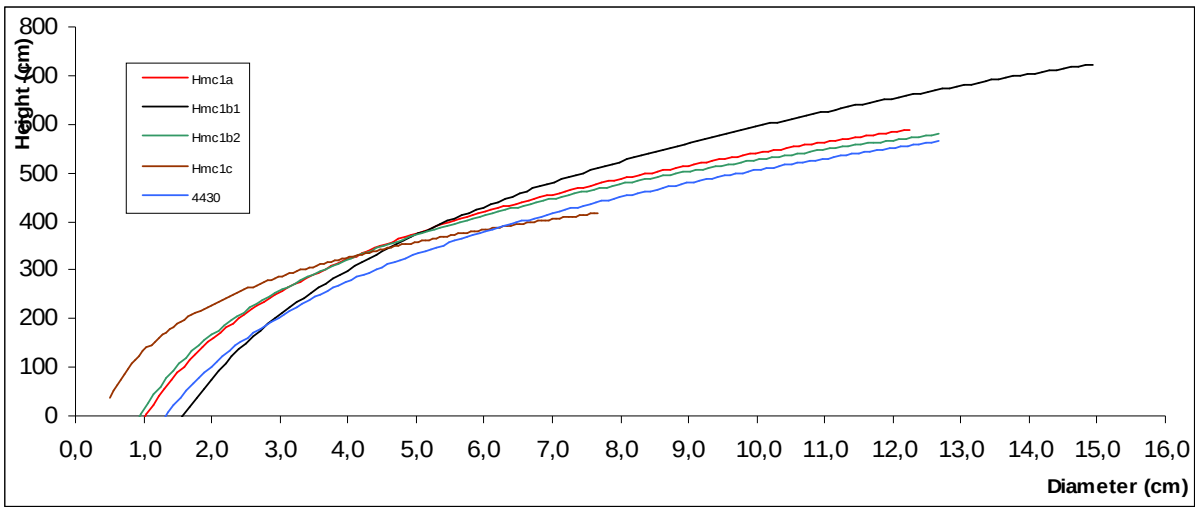

Figure 6. Differences between the average root collar diameter and average height according to the station type.

It can be easily notices on the Figure 6 that the mean of the characteristics measured for all station types is between 4 and 5 cm for the root-collar diameter and between 300 and 400 cm for the height.

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 growth in height in the previous 5 years (length between verticels).

These measurements corroborated with the root collar diameter of the catalogued species allowed the centralization of data on diameter categories (of 1.5 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. According to the station type, the spruce exhibits the characteristics from the Table 5.

Table 5

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

Root collar diameter category (cm)	*No. of seedlings*	*Projection (cm^2)*	*V1 (cm)*	*V2 (cm)*	*V3 (cm)*	*V4 (cm)*	*V5 (cm)*
		Hmc1a					
0.5-2.0	74	1717	86	6.4	8.9	6.4	9.4
2.0-3.5	32	2478	8.4	6.1	7.8	6.3	8.7
3.5-5.0	34	3147	8.4	6.2	8.1	6.4	8.8
5.0-6.5	112	5078	8.5	6.6	9	6.5	9.5
6.5-8.0	95	8134	8.5	6.5	8.4	6.8	8.7
8.0-9.5	70	11781	9.1	6.8	9.2	6.8	9.5
9.5-11.0	11	24387	9.2	6.5	9.5	6.8	9.8
11.0-12.5	7	48743	10.2	7.8	9.8	8.2	11.2
Total Hmc1a	435						
		Hmc1b1					
0.5-2.0	2	1879	8.2	6.5	9.1	7.1	8.5
2.0-3.5	21	2348	8.5	6.9	8.9	6.5	8.6
3.5-5.0	24	3287	9.2	6.9	9.8	7.8	8.9
5.0-6.5	24	5173	9.4	7.8	10.5	6.8	8.8
6.5-8.0	30	9027	9.5	8.1	9.7	7.3	9.5
8.0-9.5	33	12781	10.5	8.5	10.2	8	9.1
9.5-11.0	30	15467	11.5	8.9	11.5	9.1	10
14.0-15.5	14	102748	22.5	18.8	19.8	21.5	18.4
Total Hmc1b1	178						
		Hmc1b2					
0.5-2.0	12	1974	8	6.3	8.8	6.8	8.1
2.0-3.5	5	2874	8.1	6.4	8.4	6.7	8.1
3.5-5.0	78	3349	8.9	6.8	9.4	7.7	8.7
5.0-6.5	70	7024	9.3	7.7	10.4	6.8	8.4
6.5-8.0	22	9784	9.5	8.7	9.1	7	8.9
8.0-9.5	14	13485	10	8.1	9.9	8.1	8.9
9.5-11.0	8	18794	11.2	8.4	10.9	8.4	9.4
11.0-12.5	3	51487	12.5	10.5	11.8	9.8	10.4
12.5-14.0	21	68475	15.4	11.2	13.4	10.5	11.8
Total Hmc1b2	233						
		Hmc1c					
0.5-2.0	3	2104	8.1	6.1	8.9	7.2	8.4
5.0-6.5	19	7457	9.1	7.9	11	7.5	9.7
6.5-8.0	23	9741	9.4	8.4	8.9	6.8	8.7
Total Hmc1c	45						
		4430					
0.5-2.0	2	1827	10.2	7.8	9.5	6.4	7.9
2.0-3.5	105	2973	8.5	6.4	8.3	6.9	7.9
5.0-6.5	2	8014	9.4	7.9	11.4	8.9	8.9
11.0-12.5	15	54894	13.2	11.1	11.8	9.9	11.3
12.5-14.0	16	73346	16.2	12.5	14.3	11.4	12.1
Total Hmc1c	140						
Total Valea Dochii Mo	1031						

Following we will explain what is the significance for the terms Hmc1a, Hmc1b1, Hmc1b2, Hmc1c and 4430, from the Table 5.

Hmc1a – 435 catalogued seedlings, diameters between 0.5 cm and 12.5 cm, drip-line projection from 1717 cm^2 (average radius of the circle describing the crown's projection of 23.38 cm) for the category 0.5-2.0 cm, up to 48743 cm^2 (average radius of the circle describing the crown's projection of 124.59 cm) with annual growths from 8.6 cm up to 10.2 cm in the last year and from 9.4 cm up to 11.2 cm annual growth from 5 years ago.

Hmc1b1 – 176 catalogued seedlings, diameters between 0.5 cm and 15.5 cm, drip-line projection from 1879 cm^2 (average radius of the circle describing the crown's projection of 24.46 cm) for the category 0.5-2.0 cm, up to 10748 cm^2 (average radius of the circle describing the crown's projection of 180.89 cm) with annual growths from 8.2 cm up to 22.5 cm in the last year and from 8.5 cm la 18.4 cm annual growth from 5 years ago.

Hmc1b2 – 233 catalogued seedlings, diameters between 0.5 cm and 14 cm, drip-line projection from 1974 cm^2 (average radius of the circle describing the crown's projection of 25.07 cm) for the category 0.5-2.0 cm, up to 68475 cm^2 (average radius of the circle describing the crown's projection of 147.67 cm) with annual growths from 8.0 cm up to 15.4 cm in the last year and from 8.1 cm la 11.8 cm annual growth from 5 years ago.

Hmc1c – 45 catalogued seedlings, diameters between 0.5 cm and 8.0 cm, drip-line projection from 2104 cm^2 (average radius of the circle describing the crown's projection of 25.89 cm) for the category 0.5-2.0 cm, up to 9741 cm^2 (average radius of the circle describing the crown's projection of 55.7 cm) for the category 6.5-8.0 cm, with annual growths from 8.1 cm up to 9.4 cm in the last year and from 8.4 cm la 8.7 cm annual growth from 5 years ago.

4430 – 140 catalogued seedlings, diameters between 0.5 cm and 14.0 cm, drip-line projection from 1827 cm^2 (average radius of the circle describing the crown's projection of 24.12 cm) for the category 0.5-2.0 cm, up to 73346 cm^2 (average radius of the circle describing the crown's projection of 152.84 cm) with annual growths from 8.5 cm up to 16.2 cm in the last year and from 7.9 cm la 12.1 cm annual growth from 5 years ago.

From the point of view of the measured characteristics, it can be seen that the spruce has developed the largest crown (largest surface of the drip-line projection) and the greatest annual growth (V1, V2, V3, V4 and V5) in station types Hmc1b1, values which are in direct correlation with the also superior values of the root-collar diameter and height recorded by this species on this type of station.

Conclusions. There is a strong correlation (r=0.86) between the root collar diameter and height, which have developed relatively uniformly. However, the best development was recorded on station types Hmc1b1 - stable heap banks, with slopes under 20°, from the sub-mountain - mountain region, beech sub-region, consisting of acid rocks, generally with coarse texture.

Total number of catalogued seedlings 1.031, out of which 691 have experienced height growths over 1.30 m (67.02%); the highest percentage achieved from this point of view is on the same station type as in the case of the root-collar diameter and height, with a percentage of 81%.

The greatest projection of the drip-line and the greatest size of the distance between the verticels was exhibited also on station type Hmc1b1.

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

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