

## RESEARCHES REGARDING THE VEGETATION RECONSTRUCTION IN A FORMER BAUXITE QUARRY IN THE PADUREA CRAIULUI MOUNTAIN, ROMANIA

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**Abstract.** The paper is based on the researches carried out during 2005–2008 in the former bauxite quarry in Zece Hotare, the Bihor county. The bauxite exploitation stopped in 1998 and during 2004–2005 important works took place. An experiment with acacia trees and different variants of fertilisation were realised, too. The determinations regarding the lengths of the acacia plants emphasised the biggest increase in the variant with 6 kg manure/hole and  $N_{120}P_{120}K_{120}$  applied at the planting. In the experiment with spruce trees planted on the hill with and without works against erosion, the biggest plants annual increase was registered in the variant with works against erosion. The presence of the natural vegetation increased every year. The slope (10, 20, 31, and 44% with mattresses and of 44% without mattresses) had a very big influence on the installation of the herb natural vegetation. On the smallest slopes the vegetation (*Calamagrostis epigeios*, *Tussilago farfara*, *Fragaria vesca*, *Euphorbia cyparissias*, *Viola odorata*, *Taraxacum officinale*, *Polytrichum commune*, *Cirsium arvense*) was more present. The wooden vegetation was represented by *Salix alba* and *Betula pendula* and by *Fagus sylvatica* plants in the area near the forest of *Fagus sylvatica*.

**Keywords:** vegetation, acacia, spruce tree, former bauxite quarry.

### AIMS AND BACKGROUND

The paper presents the vegetation reconstruction in the former bauxite quarry in Zece Hotare, the Bihor county after 10 years of the end of bauxite exploitation.

The Padurea Craiului mountain is the part of the Western Carpathian situated between the Crisul Repede river and Crisul Negru river. There were the most important bauxite reserves of Romania and the exploitation study started after 1900. Chemical properties and the mineralogy of the bauxite of the Padurea Craiului mountain were reported by Vadasz (1924), Zamfirescu (1931), Racileanu (1957), Patruilus (1956), Pauliuc (1958), Preda (1962)<sup>1–3</sup>.

The vegetation of the Padurea Craiului mountain includes pasture, forest of *Picea abies* and forest of broad-leaved trees: *Fagus sylvatica*, *Carpinus betulus*, *Acer pseudoplatanus*, *Ulmus montana*, *Fraxinus excelsior*, *Cerasus avium*, *Acer*

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*campestre*, *Betula pendula*, *Sorbus aumparia*, *Salix caprea* and *Juglans regia*. Along the rivers, some specific species can be met: *Salix alba*, *Salix purpurea*, *Salix triandra*, *Populus nigra*, *Alnus glutinosa*, *Carex* sp., *Juncus inflexus*, *Iris pseudoacorus*. There are different vegetation associations in the different areas of the mountain<sup>4-6</sup>.

Herb natural vegetation from limitrophe area of the former bauxite quarry in Zece Hotare, the Padurea Craiului mountain, is represented by *Poa pratensis*, *Tus-siloga farfara*, *Cirsium arvense*, *Rubus caesius*, *Euphorbia Cyparissias*, *Fragaria vesca*, *Viola adorata*, *Toraxacum officinale*, *Polytrichum commune*, etc. Woden vegetation is represented by *Fagus silvatica*, *Betulus carpenus*, *Betula pendula*, *Salix caprea*, *Salix alba*<sup>7-10</sup>.

Planting of the vegetation in the former bauxite quarry is a complex process. This process is influenced both by the limitrophe natural vegetation and by the antropic activity<sup>11-13</sup>.

## EXPERIMENTAL

The researches were carried out during 2005–2008 in the Padurea Craiului mountain, in the former bauxite quarry in Zece Hotare, the Bihor county. The surface of the former quarry is 10 ha. The exploitation of bauxite ended in 1998. In 2004 and 2005 large-scale works were started for setting up the levelling and acacia trees (*Robinia pseudoacacia*) were planted on the levelled area as well as spruce trees (*Picea abies*) on the slope area.

An experiment regarding the influence of fertilisation on the annual growth of acacia trees (*Robinia pseudoacacia*) was placed in the upper third level of the quarry. The trees were planted in 2005, the distance on the rows was 1 m and the distance between the rows was 2 m. The dimensions of the planting hole were 40 × 40 × 40 cm. The following variants were studied: V<sub>1</sub> – control, no fertiliser; V<sub>2</sub> – N<sub>120</sub>P<sub>120</sub>K<sub>120</sub> (24 g complex fertiliser/hole); V<sub>3</sub> – manure 30 t/ha (6 kg/hole); V<sub>4</sub> – manure, 30 t/ha + N<sub>120</sub>P<sub>120</sub>K<sub>120</sub> (6 kg +24 g/hole). The experiment was placed using the block method in 4 replications. Every plot had a number of 20 plants. After being planted, each sapling was watered with 16 l of water, which ensured a 95% planting success ratio. Annual growths were determined for 40 plants in each variant (10 plants × 4 replications). Rainfall registered during the research studied were 815.8 mm in 2005, 872.0 mm in 2006, 585.2 mm in 2007. The data about acacia tree height were studied using the variance analysis method<sup>14,15</sup>.

The beech mattresses with a 2-m distance between the rows were made on the hillside of the quarry.

## RESULTS AND DISCUSSION

*Acacia (Robinia pseudoacacia)* planting on the former quarry and fertilisers influence of annual growths. The acacia trees (*Robinia pseudoacacia*) used for planting had close heights and the variance analysis emphasises this fact because there are no differences between the heights of the trees used in the 4 variants studied (Table 1).

**Table 1.** Average height of the acacia trees (*Robinia pseudoacacia*) used in the experiment with fertilisers from former bauxite quarry in Zece Hotare (in planting, 2005)

Variant	Height		Differences		Statistical significance
	(cm)	(%)	(cm)	(%)	
1. Control	25.0	100.0	–	–	control
2. N <sub>120</sub> P <sub>120</sub> K <sub>120</sub>	26.7	106.8	1.7	6.8	–
3. Manure 30 t/ha	25.5	102.0	0.5	2.0	–
4. Manure 30 t/ha + N <sub>120</sub> P <sub>120</sub> K <sub>120</sub>	26.0	104.0	1.0	4.0	–

LSD 5% = 4.1; LSD 1% = 7.6; LSD 0.1% = 3.5.

The determinations from the end of 2006 emphasise the average growth of 6.3 cm in the control, of 10.9 cm in the variant with chemical fertilisers, of 10.5 cm in the variant with manure and of 14.4 cm in the variant with manure + chemical fertilisers. There are differences (6.3 and 4.7 cm) statistically significant in comparison with the control in the variant with chemical fertiliser and manure. The biggest difference (15.1 cm, 48.2%) in comparison with the control was registered in the variant with manure + N<sub>120</sub>P<sub>120</sub>K<sub>120</sub> (Table 2).

**Table 2.** Influence of fertilisers on the acacia trees (*Robinia pseudoacacia*) height from former bauxite quarry in Zece Hotare (in planting, 2006)

Variant	Height		Differences		Statistical significance
	(cm)	(%)	cm	%	
1. Control	31.3	100.0	–	–	Control
2. N <sub>120</sub> P <sub>120</sub> K <sub>120</sub>	37.6	120.1	6.3	–	x
3. Manure 30 t/ha	36.0	115.0	4.7	–	x
4. Manure 30 t/ha + N <sub>120</sub> P <sub>120</sub> K <sub>120</sub>	46.4	148.2	15.1	–	xxx

LSD 5% = 3.9; LSD 1% = 6.6; LSD 0.1% = 13.0.

In 2007, the height growths were bigger than in 2006: 9.0 cm in the control, 12.2 cm in the variant with chemical fertilisers, 14.6 cm in the variant with manure and 19.7 cm in the variant with manure + N<sub>120</sub>P<sub>120</sub>K<sub>120</sub>. In comparison with the control, there are distinctly significant differences (9.6 cm; 10.3 cm) in the variants with chemical fertilisation and with manure and very statistically significant (19.8 cm) in the variant with manure + N<sub>120</sub>P<sub>120</sub>K<sub>120</sub> (Table 3).

**Table 3.** Influence of the fertilisers on the acacia trees (*Robinia pseudoacacia*) height from former bauxite quarry in Zece Hotare (in planting 2007)

Variant	Height		Differences		Statistical significant
	(cm)	(%)	(cm)	(%)	
1. Control	40.3	100.0	–	–	control
2. N <sub>120</sub> P <sub>120</sub> K <sub>120</sub>	49.8	123.6	9.6	23.6	xx
3. Manure 30t/ha	50.6	125.6	10.3	25.6	xx
4. Manure 30t/ha + N <sub>120</sub> P <sub>120</sub> K <sub>120</sub>	60.1	149.1	9.8	49.1	xxx

LSD 5% = 4.0; LSD 1% = 7.2; LSD 0.1% = 14.8.

*Reconstruction of the natural vegetation.* In August 2006, there were 13 plants/m<sup>2</sup> of herb natural vegetation in the low levelled area of the former bauxite quarry. The species adapted for water logging had the highest frequency (23%): *Juncus inflexus*, *Equisetum arvense*, *Polygonum persicaria* (Fig. 1); *Tussilago farfara* had the same frequency; *Calamagrostis epigeios* had a frequency of 8%. In the high levelled area the number of plants were smaller with 47% and flowering structure is different: *Tussilago farfara* represented 72%, *Cirsium arvense* and *Rubus caesius* represented 14% (Table 4).



**Fig. 1.** *Juncus inflexus*, vegetation in the low levelled area of the former bauxite quarry, Zece Hotare, Romania

*Tussilago farfara* was presented on the hillside of the former bauxite quarry and *Poa pratensis* was met on the beech tree forest from limitrophe area, only (Table 4).

**Table 4.** Natural vegetation of different areas of the former bauxite quarry in Zece Hotare, 2006

Area of determination	Total (plants/ m <sup>2</sup> )	Species 1 (plants/ m <sup>2</sup> )	Species 2 (plants/ m <sup>2</sup> )	Species 3 (plants/ m <sup>2</sup> )	Species 4 (plants/ m <sup>2</sup> )	Species 5 (plants/ m <sup>2</sup> )	Species 6 (plants/ m <sup>2</sup> )	Species 7 (plants/ m <sup>2</sup> )	Species 8 (plants/ m <sup>2</sup> )	Species 9 (plants/ m <sup>2</sup> )	Species 10 (plants/ m <sup>2</sup> )				
1. Low levelled area	13	100	3	23	-	-	-	1	8	-	-	3	23	3	23
2. High levelled area	7	100	5	72	1	14	-	1	14	-	-	-	-	-	-
3. Hillside with mat-tress	5	100	4	80	-	-	-	-	1	20	-	-	-	-	-
4. Hillside without matress	3	100	3	100	-	-	-	-	-	-	-	-	-	-	-
5. Beech tree forest from limitrophe area	8	100	7	88	-	-	8	100	-	-	-	-	-	-	-

Species 1: *Tussilago farfara* sp., 2: *Cirsium arvense* sp., 3: *Poa pratensis* sp., 4: *Rubus caesicius* sp., 5: *Calamagrostis epigeios* sp., 6: *Hypericus perforatum* sp., 7: *Equisetum arvense* sp., 8: *Polygonum persicaria* sp., 9: *Juncus inflexus* sp., 10: *Alium ursinum*.

In August 2007, the number of the herb plants increased in the all locations of the former bauxite quarry. The increase was 108% in the low levelled area, 71.5% in the high levelled area, 200% in the area of the hillside with mattresses and 133.4% in the area of the hillside without mattresses. In comparison with 2006, *Cirsium arvense* and *Rubus caesius* appeared in the low levelled area and *Hypericus perforatum* appeared in the high levelled area. The importance of the mattresses on the hillside of the quarry in the vegetation reconstruction is emphasised by the number of plants (15 plants/m<sup>2</sup>) more than 114.3% in comparison with the number of plants (7 plants/m<sup>2</sup>) on the hillside without mattresses. The flowering structure was larger than in 2006, *Cirsium arvense* appeared on the hillside with mattresses and *Rubus caesius* on the hillside without mattresses (Table 5).

Determinations from April 2008 show a bigger number of plants in the all variants studied. In the levelled variants, the number of plants increased in comparison with 2007 with 34.7% in the low area and with 16.7% in the high area; the number of plants increased on the hillsides with 40% in the variant without mattresses and with 73.4% in the variant with mattresses (Table 6). There is *Alium ursinum* in the beech tree forest of limitrophe area (Table 6). The wooden vegetation is presented in different areas of the former bauxite quarry both in the levelled area and on the hillside. *Salix alba* and *Betula pendula* were determined. *Fagus silvatica* was determined in the area near the limitrophe beech tree forest (Fig. 2).



**Fig. 2.** Wooden vegetation in the former bauxite quarry, Zece Hotare, Romania

**Table 5.** Natural vegetation of different areas of the former bauxite quarry in Zece Hotare, 2007\*

Area of determination	Total (plants/ m <sup>2</sup> )	Species 1 (plants/ m <sup>2</sup> )	Species 2 (plants/ m <sup>2</sup> )	Species 3 (plants/ m <sup>2</sup> )	Species 4 (plants/ m <sup>2</sup> )	Species 5 (plants/ m <sup>2</sup> )	Species 6 (plants/ m <sup>2</sup> )	Species 7 (plants/ m <sup>2</sup> )	Species 8 (plants/ m <sup>2</sup> )	Species 9 (plants/ m <sup>2</sup> )	Species 10 (plants/ m <sup>2</sup> )
1.Low levelled area	27	100	5	19	1	3	-	-	-	-	-
2. High levelled area	12	100	8	67	2	17	-	-	1	8	-
3. Hillside with mat-tress	15	100	12	80	1	7	-	-	2	13	-
4. Hillside without mattress	7	100	6	86	-	-	-	-	1	14	-
5. Beech tree from limitrophe area	8	100	-	-	-	-	-	-	8	100	-

\* List of species as in Table 4.

**Table 6.** Natural vegetation of different areas of the former bauxite quarry in Zece Hotare, 2008\*

Area of determination	Total (plants/ m <sup>2</sup> )	Species 1		Species 2		Species 3		Species 4		Species 5		Species 6		Species 7		Species 8		Species 9		Species 10		
		(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	(plants/ m <sup>2</sup> )	(%)	
1. Low levelled area	35	100	7	20	1	3	-	-	1	3	1	3	-	-	7	20	4	11	8	23	6	17
2. High levelled area	20	100	10	50	4	20	-	-	3	15	-	3	15	-	-	-	-	-	-	-	-	-
3. Hillside with mat-tress	26	100	19	73	3	12	-	-	-	-	4	15	-	-	-	-	-	-	-	-	-	-
4. Hillside without mattress	16	100	14	88	-	-	2	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Beech tree forest from limnitrophe area	12	100	-	-	-	-	9	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-

\* List of species as in Table 4.



## CONCLUSIONS

The researches carried out during 2005–2008 in the former bauxite quarry in Zece Hotare, the Padurea Craiului mountain, emphasise the importance of the fertilisation system in the vegetation planting. Three variants of fertilisers ( $N_{120}P_{120}K_{120}$ ; manure 30 t/ha; manure 30 t/ha +  $N_{120}P_{120}K_{120}$ ) were studied and the variant with organic fertilisation + mineral fertilisation determined the biggest annual growths of the acacia (*Robinia pseudoacacia*) in comparison with the control. Organic and mineral fertilisation determined annual growths, very statistically significant, too.

Herb natural vegetation from former bauxite quarry was studied in 5 locations. The number of plants increased every year. In 2006, 13 plants/m<sup>2</sup> were determined in the low levelled area, 7 plants/m<sup>2</sup> in the high levelled area, 5 plants/m<sup>2</sup> on the hillside with mattresses, 3 plants/m<sup>2</sup> on the hillside without mattresses and 8 plants/m<sup>2</sup> in the beech tree forest of limitrophe area. The number of plants increased in 2007 with 107.7, 71.5, 160 and 66.7%; in the beech tree forest, the same number of plants was determined. The number of plants from April 2008 increased in comparison with 2006 with 169.3% in the low levelled area, with 185.8% in the high levelled area, with 420% on the hillside with mattresses and with 133.7% on the hillside without mattresses; in the beech tree forest, *Alium ursinum* was present, too.

*Tussilago farfara* was the species determined in the all areas of the former bauxite quarry. In the low levelled area, the dominant species which prefer the water logging were met: *Juncus inflexus*, *Equisetum arvense*, *Polygonum persicaria*, *Calamagrostis epigeios*, *Tussilago farfara*; *Cirsium arvense* and *Rubus caesius* were determined, too. In the high levelled area, dominant species was *Tussilago farfara*; *Cirsium arvense*, *Rubus caesius* and *Hypericus perforatum* were determined, too. On the hillside with mattresses, *Tussilago farfara* was the dominant species and *Calamagrostis epigeios* and *Cirsium arvense* were met, too. Only *Tussilago farfara* was determined on the hillside without mattresses.

The wooden vegetation is represented by *Solix alba* and *Betula pendula* and by *Fagus silvatica* in the area near the limitrophe beech tree (*Fagus silvatica*) forest.

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