CULTIVATING THE WASTE HEAPS FROM MOLDOVA NOUĂ WITH FOREST SPECIES THAT HAVE AN ENERGTIC POTENTIAL

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The purpose of the works realized on the waste heaps from Moldova Nouă was to stabilize them with the help of vegetation in general and especially with forest vegetation. Furthermore, their purpose was to ameliorate the environment condition through the influences exerted by the presence of vegetation and also to offer a landscape value for the entire affected area, to restore its beauty. The researches realized now were achieved with the purpose of comparing them with the measurements realized in the year 2000. This comparison furnishes important conclusions from an energetic, productive, ecological and landscape point of view.

Keywords: waste heaps, forest vegetation

1. Introduction

The waste heaps, of which we can metaphorically say that they are "fragments of desert in full temperate area" are presenting two distinctive elements particular to the desert and in general for the arid areas of our planet: the sand (sterile) and the strong wind that handles it, elements that can be found in the area of Moldova Nouă.

The presence of these threatening deposits in their immensity (approximately 30 million of sterile mc on an area of 130 ha) is linked with the evolution of the modern human society which is characterized by an exaggerated industrialization that produces not only consumer goods, but also waste and pollution. The waste heaps from Moldova Nouă are thus the price payed by humans for the past rapid growth of mining from this area without taking the necessary methods for the protection of the environment. Due to a series of human interventions, an important part of the surface of these waste heaps represents today a physical-geographical complex very different form the one before the execution of stabilization and amelioration works. Through afforestation there were accomplished important territorial changes and ameliorations in the edaphic sphere and from a landscape point of view.

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The waste heaps are situated on the left bank of the Danube, approximately near "Ostrov" island, where the river makes a meander. The town of Golubat (fig. 1) can be found on the Serbian shore. The total area, taking also into consideration the unoccupied spaces between the waste heaps, is of approximately 200 ha.

Fig. 1 – The waste heaps complex from Moldova Nouă (Google Earth)

2. Setting the cultures on the waste heaps from Moldova Nouă

Setting the cultures on the waste heaps from Moldova Nouă was accomplished in the period 1988 – 1989. We have used three methods: planting in a field covered with vegetal soil- with very good results, planting in holes with an addition of nutrient substratum– with satisfactory but unequal results, planting in a sterile filed- with weak results at that time.

In the case of sandy waste heaps, the method of bringing soil from another part and posing it on the surface of the waste heaps was a sure method for good results. The soil used to cover the waste heaps in order to ameliorate the trophic conditions as well as to block the dashing of the sand from their surface comes from an adjacent meadow, its type being thus meadow brown eubasic. In order to control very fast the surface of the waste heaps and to discourage the environment's pollution, we have resorted to a strategy that has proven very efficient: planting a larger number of plants for each hectare and using a diversified assortment of species even though the soil and district conditions were almost identical.

Planting in holes with an addition of nutrient substratum is another method that consisted in the introduction of a quantity of vegetal soil or of soil mixed with sawdust at the root of the plants. The purpose was to give the plants the nutritional impulse that they needed in order to develop. Two methods were applied: vegetal soil in natural condition, a bucket for each plant (approximately 10 dm^3) and vegetal soil combined with sawdust in an equal proportion. This process also gave us the opportunity to extend the assortment of species previously used on the waste heaps, introducing thus both forest species as well as fruit-trees. The results are promising, but unequal, depending on each species.

The decision to plant in sterile land was generated by the observation that in the last 4-5 years before the experiment naturally regenerated oleaster plantlets have appeared. In the spring of 1994 direct plantations in sterile fields were accomplished using oleaster, locust and willow thorn on alternative rows. However, the success of these plantations is not the one desired. The research and development of the executed plantations were slow and the growths were inferior in comparison with the ones from the covered fields. The vegetation state was weak and with low perspectives for resistance without interventions (irrigations, fertilizations etc.).

Using the stational characterization of the fields, we have established the most efficient measures in order to cease as soon as possible the aeolian and pluvial erosion located on the slopes of the floating heaps. We have tried to execute the necessary work as soon as possible. The main forest species that were cultivated on Moldova Nouă waste heaps and that had the best results concerning their growth and development were the locust and oleaster. Besides this, the assortment of the cultivated species also contained the following species: Canadian poplar, American cherry, ailanthus, willow thorn. By testing a large number of woody plants we have selected 3 main forest species, Eleagnus angustifolia (oleaster), Robinia pseudacacia (locust) and Hypophae rhamnoides (willow thorn). They have created very fast a specific phitomedium (shadow, vegetal remains, slowing down the winds, the retention on water, etc.) favourable for the installation of numerous vegetal species.

3. Particular investigations – research methodology

The investigations that were realized on "Boşneag" waste heaps at 10 years from the last observations and measurements of the plantations were accomplished through the establishment of the plantation's biomass that was realized in the past in order to determine their energetic potential. This fact was accomplished through the determination of the total volume of woody material, subterranean and supraterranean and through the determination of the wood density for the species present on "Boşneag" waste heaps: locust and oleaster. The

investigations were realized on 3 square sample areas of 100 mp each, areas that were realized with a tape measure. The layout of the surfaces was realized on horizontal field on a woody plateau near the slope.

Measurements concerning the diameter and height of the trees were realized on each sample surfaces totalizing a number of 170 copies. The proportion on species is the following: 52% locust, 48% oleaster. Six trees were harvested from the 3 sample surfaces: a locust and an oleaster from each sample surface with an average diameter (4 - 6 cm for locust and 2 - 4 cm for oleaster). For each tree the root was also extracted in order to determine the total volume. In order to calculate the volume for the 6 trees we have used the section method but also the xilometre method for the tree's spindle. The xilometre method was used separately only for the roots and branches.

Implement cores were extracted from 30 locust and oleaster exemplars in order to determine the wood's density. The volume of these implement cores was determined through the total diving in water and measuring the volume of the displacement liquid. The apparent density of the wood in dry state and respectively in humid state was determined by using the volume of the implement cores with the help of the 5 ml tube and the mass that was determined with the help of the electronic scale. The following formulas were used:

$$\rho_{a_0} = \frac{m_0}{V_{a_0}}, \text{ where:}$$

ρ_{a_0} is the apparent density of the wood in a total dry state;

m_0 is the mass of the totally dry implement core;

V_{a_0} is the volume of the totally dry implement core.

$$\rho_{a_u} = \frac{m_u}{V_u}, \text{ where:}$$

ρ_{a_u} is the apparent density of the humid wood;

m_u is the mass of the implement core at a humidity of $0\% < u < 30\%$;

V_u is the volume of the implement core at the same u humidity.

4. The biometric characteristics of the plantations

After the processing of the collected information the following data concerning the average height, average diameter as well as the growth in comparison with the year 2000, the year of the last biometric measurements have resulted:

Concerning the repartition of the trees on diameter categories it can be ascertained that the largest number of trees have the diameter between 4 and 6 cm.

In the case of the locust because of its biggest proportions and its vigorous growth the biggest number of trees is comprised in the 4-6 cm category.

Table 1

The biometric characteristics of the plantations

Species	Biometric characteristics (2010)		Biometric characteristics (2000)		Average growth	
	Average height (m)	Average diameter (cm)	Average height (m)	Average diameter (cm)	In height (m)	In diameter (cm)
Locust	5,9	6	0,9	1	5	5,1
Oleaster	3,2	3,8	0,8	0,8	2,4	3
TOTAL (average)	4,55	4,9	0,85	0,9	3,7	4,05

The oleaster has registered the biggest number of trees in the 2-4 cm category. In many cases the trunk was shrubby and ramified under 1,3 m, the height at which the diameter was measured.

The following table presents the tree's repartition on diameter categories.

Table nr.2

The repartition of trees on diameter categories

Species	Diameter categories (cm)									Total
	<2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	
Locust	3	18	26	20	9	6	3	2	1	88
Oleaster	8	38	23	9	4					82
Total	11	41	49	29	13	6	3	2	1	170

5. The correlation between height and diameter for the „Boşneag" waste heaps

Even though all the plantations that we have studied had the same age, their proportions are different because of the competition conditions, biotic and abiotic factors. This chapter presents the situation in which the competition between individuals as well as the biotic and abiotic factors is generating different growths in height and diameter even though the species have the same age. The heights and diameters are connected. For the locust (Fig. 2) this connection is more significant in comparison with the oleaster (Fig. 3), especially because it has a shrubby development caused by a deficiency of light. The locust had a faster growth in height, a slender gait and has reached a superior ceiling.

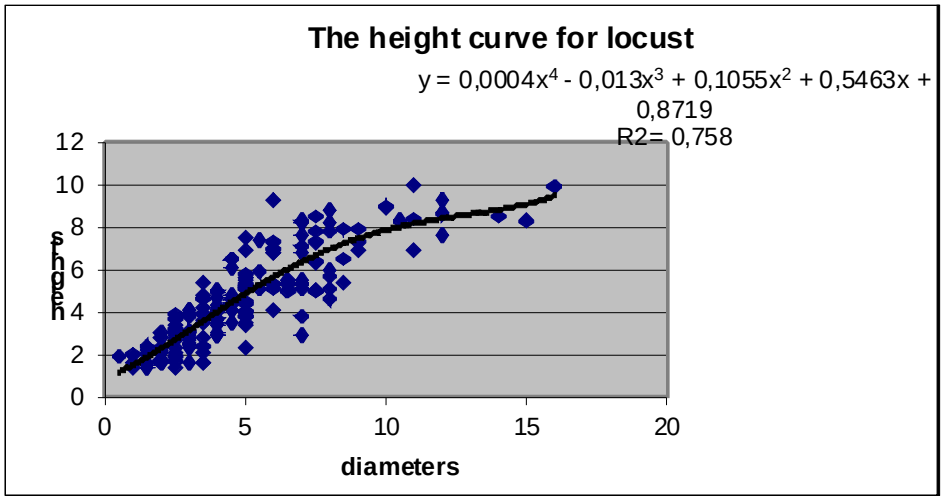

Fig. 2 – The height curve for locust

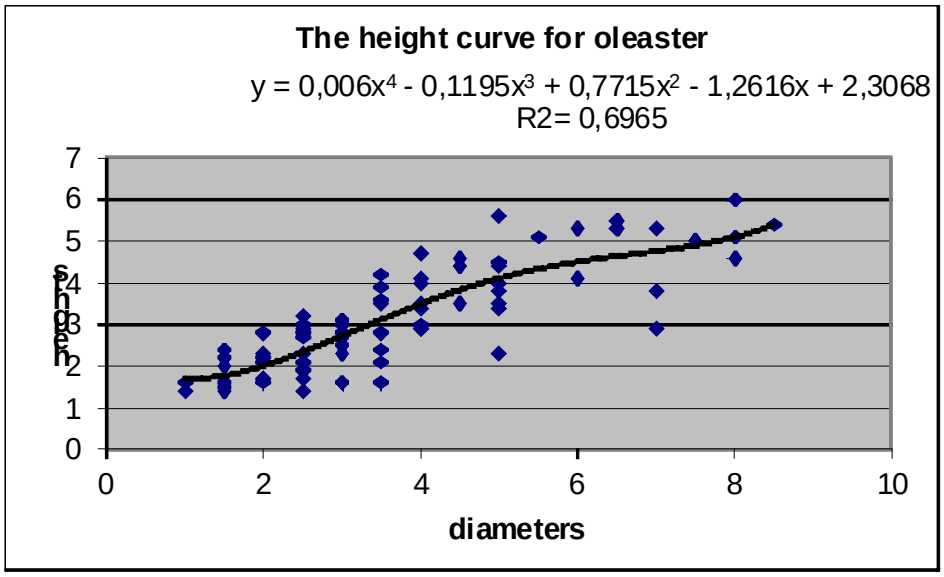

Fig. 3 – The height curve for oleaster

6. The woody mass volume of the plantations

In order to establish the woody mass volume for the plantations we have taken into consideration the volume of the average tree. Then we have

extrapolated this value for the total number of trees for one ha. Thus we can obtain the ha volume of the plantations.

The volume of the average tree was determined as an average of the volume of the extracted trees. The calculation for each extracted tree was realized on tree parts, more precisely on the root, trunk, crown.

The root and crown volumes were determined through xilometration while the volume of the trunk through calculation via the section method. As a mean of control, the trunk's volume was also determined through xilometration.

The following table presents the results obtained through the determination of the volume of the extracted trees and of the average tree for each type of species.

Table 3

The volume of the extracted trees and the volume of the average tree

Species	Sample area	Volume fus			Root volume (xilometer method)	
		Section method	Xilometer method			
		mc	litre	mc	litre	mc
Locust	1	0,0124	10,6	0,0106	4,7	0,0047
	2	0,0070	6,2	0,0062	2,7	0,0027
	3	0,0085	7,3	0,0073	2,8	0,0028
Oleaster	1	0,0031	2,6	0,0026	1,9	0,0019
	2	0,0035	3,2	0,0032	2,3	0,0023
	3	0,0022	1,9	0,0019	2	0,0020

Species	Sample area	Crown volume (xilometer method)		Tree's total volume	Average tree volume	Average tree volume without root
		litre	mc	mc	mc	mc
Locust	1	2,8	0,0028	0,0199	0,0156	0,0122
	2	2,3	0,0023	0,0120		
	3	3,2	0,0032	0,0148		
Oleaster	1	2,4	0,0024	0,0074	0,0075	0,0054
	2	3	0,0030	0,0088		
	3	2,1	0,0021	0,0063		

The trunk's volume determined through the xilometer method has a lower value than that determined through the section method due to the losses created by the section of the trunk with the mechanic saw. Thus, based on the average tree volume we can determine by extrapolation the total volume of the measured trees with or without the root as well as the total volume of woody mass for a ha. This data is rendered in the table 4.

The number of trees for a ha was determined through the extrapolation of the number of trees measured in the 3 sample surfaces, totalizing 300 mp. In the case of locust, the value of the woody mass volume without root is situated in the IV class of production according to "The biometry of Romania's trees and stands biometry."

Table 4

The plantations volume of woody mass for a ha

Species	Average tree volume (mc)	Average tree volume without root (mc)	Number of trees for ha	Total volume (mc/ha)	Volume without root (mc/ha)
Locust	0,0156	0,0122	2933,333	45,76	35,79
Oleaster	0,0075	0,0054	2733,333	20,49	14,76
TOTAL				66,25	50,55

7. The density of the wood from the plantations situated on „Boşneag" waste heaps

The density of the wood from the plantations situated on „Boşneag" waste heaps was determined through the measurement of the gravimetrical and volumetrically characteristics and the reporting of 30 samples. Thus, from each surface 5 locust increment cores and 5 oleaster increment cores were gathered.

Thus we have determined the apparent density of the humid wood (after the gathering of the samples) as well as the apparent density of the wood in a complete dry state (after we have dried the implement cores in an oven at a temperature of 105^0 C). The following tables are presenting information concerning the volumetrically, gravimetrical and densimetrical characteristics of each sample as well as the average density expressed in kg/mc, both before and after we have dried the samples in an oven.

Table 5

The apparent density of the humid wood for the plantations situated on „Boşneag" waste heaps

Area	Species	Average density (kg/mc)
1	Locust	833.222
	Oleaster	775.159
2	Locust	834.015
	Oleaster	777.436
3	Locust	883.074
	Oleaster	729.491
Average density for locust		850.104
Average density for oleaster		760.695

Tabel 6

The apparent density of the completely dry wood for the plantations situated on „Boşneag" waste heaps

Area	Species	Average density (kg/mc)
1	Locust	701.298
	Oleaster	628.165
2	Locust	729.247
	Oleaster	584.696
3	Locust	764.750
	Oleaster	592.900
Average density for locust		731.77
Average density for oleaster		601.92

8. Conclusions

The purpose of the works realized on the waste heaps from Moldova Nouă was to stabilize them with the help of vegetation in general and especially with forest vegetation. Furthermore, their purpose was to ameliorate the environment condition through the influences exerted by the presence of vegetation and also to offer a landscape value for the entire affected area, to restore its beauty. The researches realized now were achieved with the purpose of comparing them with the measurements realized in the year 2000. This comparison furnishes important conclusions from an energetic, productive, ecological and landscape point of view, conclusions that are rendered here.

For locust, the woody mass volume without root of 35,79 mc/ha reveals a pretty good development and a good production of wood. This value, according to biometry, situates the plantations in the IV class of production. The total volume, encompassing the root, is of 20,49 mc/ha. For oleaster, the volume without root is of 14,76 mc/ha. These numbers reveal a good productivity taking into consideration the hard vegetation conditions. Furthermore, they highlight the energetic potential of these cultures, a potential that can be improved in the case of a replacement and the introduction of a species with a higher value.

The locust and oleaster wood density in a humid and a dry conditions presented in the previous tables are also emphasizing a pretty good energetic value.

Based on the good growth and growth potential from the last 10 years we can estimate that these plantations can produce in the future more and more biomass.

The measurements realized on the heights and diameters of the trees reveal the fact that the development and growth are rather good taking into consideration the extreme conditions. In the sample areas there are trees with a diameter up to

16 and a height of maximum 10 m. This fact has lowered the wind's intensity and has allowed its covering with reed and different herbaceous species. In this way, the wind erosion phenomenon is practically stopped on these surfaces on which we have stabilized the embankments with forest vegetation. Taking into consideration their success we consider that it is necessary to extend the stabilization works on the other areas as well.

The average growth in height (5,1 m) and diameter (5,2 cm) for the locust in the last 10 years is very good taking into consideration the harsh environment conditions offered by the waste heaps. The locust has enriched the soil through the production of biomass and through its shading, fending it from drought. This fact favours the introduction of more valuable species from an ecological and productive but also esthetical and landscape point of view.

Overall, the evolution of this ecoproductive plantations we can conclude that their success is valuable and important. The growth in height, the growth in diameter and the biomass production are satisfactory taking into consideration the unfavourable vegetation conditions.

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