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WHICH WOODY SPECIES SHOULD BE USED FOR AFFORESTATION OF HOUSEHOLD DUMPS CONSISTING OF DEMOLITION MATERIALS MIXED WITH ORGANIC MATERIALS?

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Abstract

Romania has a great tradition in afforestation of diverse categories of lands, including the degraded terrains. Afforestation projects are made in accordance with the technical norms approved by normative acts. In the last two decades, even if there were hundreds of afforestation projects, the forested area didn't increase significantly. This was mainly due to the fact that the targeted areas were small and due to the very bureaucratic process. In the perspective of upcoming funds from the European Union, through the dedicated component of the Romanian Recovery and Resilience Plan, it is expected that an area of 56.700 hectares of diverse lands, other that the ones already included in the national forest fund, would be forested until 2026. In this perspective, several reforms and investments are planned. Among them, a greater flexibility of the normative acts is envisaged, especially for lands situated outside the forest fund. In this context, the present paper analyzed the proposals contained in the afforestation technical norms corresponding to group no. 121, by introducing additional criteria. In AHP, three scenarios were considered. Out of the six species recommended by the technical norms, Tree of Heaven and black locust proved to be the most preferred species for afforestation of household dumps consisting of demolition materials mixed with organic materials.

Key words*: AHP, black locust, household dump, Tree of Heaven, woody species.*

INTRODUCTION

In Romania, in the last two decades, hundreds of afforestation projects of agricultural and/or degraded lands were implemented. The vast majority of the projects were financed by the Romanian Government. For example, Ministry of Environment, Waters and Forests, through its territorial branches responsible for forestry (*i.e.* Forest Guards), and based on Law no. 100/2010 and Government Decision no. 1257/2011, is financing projects aimed at afforestation of several categories of degraded lands, unsuitable for agriculture. In the last decade, the funds were available every year, but the area afforested decreased mainly due to the very bureaucratic procedures and the lack of the attractiveness in terms of grants/ financial compensations, especially for private land owners. In addition, during the last decade, hundreds of afforestation projects were financed by the Administration of the Environment Fund (Barbu, 2021) and through sub-measure 8.1 managed by the Agricultural Payments and Intervention Agency (Enescu, 2020). Thanks to the implementation of the sub-measure 8.1., 1.266 hectares were afforested (MIPE, 2021). Even so, the afforested area (*i.e.* new forests planted on agricultural/degraded lands which were included into the forest fund and managed under forest regime) in the last two decades was, on average, around 200 hectares per year (MIPE, 2021), most of the new forests being established in the sandy soils from southern-western part of Romania, mainly in Oltenia region (Enescu, 2019).

In September 2021, the European Commission adopted Romania's Recovery and Resilience Plan, based on which the country will receive 29.2 billion EUR under the European Union's Recovery and Resilience Facility. The plan has fifteen components, the second one being Forests and Biodiversity Protection (MIPE, 2021). Afforestation and reforestation represent among the main investments, with a total budget of 730 million EUR. These investments will be managed by the Ministry of Environment, Waters and Forests through the nine territorial Forest Guards and beneficiaries

could be all categories of owners, both public and private. The main targets of these investments consist in 56.700 hectares of new forests and 3.150.000 square meters of urban green spaces (MIPE, 2021).
These investments are aligned with the targets of the European Union contained in newly adopted strategic documents, such as: Biodiversity Strategy for 2030, Green Deal and Forest Strategy for 2030 (Hermoso et al., 2022).
Moreover, new forested areas are needed from the perspective of fighting against climate change or to improve the environment (Constandache et al., 2021; Korneeva, 2021; Lupăncescu, 2021; Mușat et al., 2021).
Apparently, the initiative assumed by the Romanian Government (*i.e.* planting 56.700 hectares of new forests) should not be a great challenge taking into consideration the vast experience in terms of afforestation of several categories of lands in Romania (Palaghianu and Dutcă, 2017). In this context, any category of land, especially the degraded ones as a result of the human activities, may be considered.
The aim of this study was to highlight the most suitable woody species used for afforestation of the household dumps consisting of demolition materials mixed with organic materials in Romania.

MATERIALS AND METHODS

Black locust (*Robinia pseudoacacia* L.), Tree of Heaven [*Ailanthus altissima* (Mill.) Swingle], manna ash (*Fraxinus ornus* L.), European ash (*Fraxinus excelsior* L.), Russian olive (*Elaeagnus angustifolia* L.) and sea-buckthorn (*Hippophae rhamnoides* L.) were the six woody species recommended by the Technical Norms regarding the compositions and technologies for forest regeneration and afforestation of degraded lands (MAPPM, 2000), as the best option for afforestation of the household dumps consisting of demolition materials mixed with organic materials. According to the technical norms (MAPPM, 2000), the afforestation composition 50 Sc 25 Cn (Mj, Fr, Sl) 25 Ct (Sc: black locust, Cn: tree of Heaven, Mj: manna ash, Fr: European ash, Sl: Russian olive, Ct: sea-buckthorn) is proposed in terrains from the steppe to the hilly regions (Group no. 121).
In order to highlight the most suitable woody species for afforestation of the household dumps consisting of demolition materials mixed with organic materials, an Analytic Hierarchy Process (AHP) was performed. Within AHP, the decision problem (*i.e.* the goal of this study) was decomposed into a hierarchy sub-problems (*i.e.* the ten criteria used), each of which can be independently analyzed (Enescu, 2018). A scale ranging from 1 to 6 was used for each criterion, namely: **criterion 1** - growth rate (from 1 - very slow growing rate to 6 - very fast growing rate); **criterion 2** - vegetative propagation (from 1 - no vegetative propagation to 6 - very intense vegetative propagation); **criterion 3** - generative regeneration (from 1 - the lowest to 6 - the highest); **criterion 4** - height (from 1 - the smallest to 6 - the highest); **criterion 5** - crown density (from 1 - rare crown to 6 - very dense crown); **criterion 6** - root system (from 1 - very less developed in depth and sidewise to 6 - very developed in depth and sidewise); **criterion 7** - demand for light (from 1 - very shade tolerant to 6 - very high demand for light); **criterion 8** - soil requirements (from 1 - very high requirements to 6 - extremely low requirements); **criterion 9** - temperature requirements (from 1 - resistant to low temperatures to 6 - resistant to high temperatures) and **criterion 10** - ornamental value (from 1 - very low value to 6 - very high value), respectively. This methodology was used in similar studies aimed at highlighting the shrub species that should be used for establishment of the field shelterbelts in Romania (Enescu, 2018) and highlighting the allochthonous tree species that should be used for afforestation of salt-affected soils across Romania (Enescu, 2020). Each criterion was analyzed by the aid of Expert Choice Desktop software (version 11.5.1683). As regards the height of the criteria within the analysis, three scenarios were considered. In scenario no. 1, all ten criteria received an equal share (*i.e.* 10%), meaning that they had an equal importance.
Criteria no. 1, 6 and 8 (*growth rate*, *root system* and *soil requirements*) were considered most important in scenario no. 2 (*i.e.* with an equal share of 26.5%, while the remaining seven criteria received an equal share of 2.9%, respectively). The goal of this scenario was to

highlight the most suitable species that has simultaneous ones of the fastest growing rate and the most developed root system and they have the lowest soil requirements.
Scenario no. 3 focused on the generative and vegetative regeneration properties of the six woody species. Criteria no. 2 and 3 received an equal share of 34.6%, while the rest of the eight criteria received and equal share of 3.8%, respectively.

RESULTS AND DISCUSSIONS

A detailed description of the six woody species was made based on the information available in the specialized manuals and studies, following the ten selected criteria.
Black locust has a very fast juvenile growth rate; it has a far-reaching dimorphic root system; it has a high annual production of fast-decomposing leaves which generate a high quantity of organic matter; it can be propagated both in vegetative and generative ways; its seed maturation is annual, but vegetative propagation is the most common way of reproduction (Șofletea and Curtu, 2008; Rahmonov, 2009; Mușat, 2012; Rédei et al., 2012; Enescu and Dănescu, 2013).
Tree of Heaven has a fast growing rate; it tolerates a wide variety of climatic and edaphic conditions; it demands a warm climate and a long growing season and it is a shade intolerant species, preferring open spaces; it produces a big amount of seeds, being reported that a mature tree can produce around 300.000 seeds in a season; it has also a vigorous re-sprouting rate, its sprouts being able to reach up to 3-4 meters in height in the first year (Hu, 1979; Pan and Bassuk, 1986; Șofletea and Curtu, 2008; Enescu, 2014a).
Manna ash has a well-developed root system; it is a light-demanding species; it is suitable for a broad array of degraded lands, such as whose affected by gully erosion and landslides, being able to colonize bare terrains thanks to its plasticity, fast germination and fast growth at early ages (Constandache et al., 2002; Constandache et al., 2006; Enescu, 2015; Caudullo and de Rigo, 2016).
European ash is a medium-size tree, growing up to 25-30 m, with a strong root system; it is a mesophile species, a strong light-demanding species and it can tolerate a broad range of nutrient and water conditions, but it prefers rich soils (Șofletea and Curtu, 2008; Beck et al., 2016).
Russian olive can tolerate a wide variety of environmental conditions, being resistant both to drought and frost, withstanding temperatures ranging from -45 to $+46^0$C; it has a rapid juvenile growth rate; it can be propagated both in generative and vegetative ways, its seed dispersal being mainly done by animals and water; it can grow under a wide spectrum of soil conditions and can colonize bare lands, being suitable for several categories of degraded terrains, such as eroded soils, landslides, on tailing dumps, on mining dumps, etc. (Akbolat et al., 2008; Khamzina et al., 2009; Nețoiu, 2012; Cântar et al., 2014; Hamidpour et al., 2017).
Sea-buckthorn is a pioneer species, highly adapted to extreme soil and climatic conditions; it is a light demanding species; it can grow in a vast array of degraded terrains, being also adapted to the alkalinity and salinity; it can be propagated very easy both in vegetative and generative ways (Small et al., 2002; Bolibok et al., 2008; Covaci et al., 2009; Acharya et al., 2010; Vescan et al., 2010; Bolea and Chira, 2012; Enescu, 2014b).
AHP alternative ranking for the ten criteria in the case of the six woody species, based on the information available in scientific papers, specialized manuals and on the author's expertise, is given in Table 1.

Table 1. AHP alternative ranking

Criteria / Species	Black locust	Tree of Heaven	Manna ash	European ash	Russian olive	Sea-buckthorn
1. Growth rate	5	6	2	4	1	3
2. Vegetative propagation	5	6	1	2	3	4
3. Generative regeneration	1	6	4	5	2	3
4. Height	4	5	3	6	2	1
5. Crown density	4	1	3	5	2	6
6. Root system	5	6	3	4	2	1
7. Demand for light	3	6	2	1	5	4
8. Soil requirements	3	5	2	1	4	6
9. Temperature requirements	4	5	3	2	6	1
10. Ornamental value	6	1	3	4	5	2

Within scenario no. 1 (when all criteria received an equal share), the most preferred woody species were the Tree of Heaven, black locust and European ash, respectively (Figure 1).
In scenario no. 2, Tree of Heaven and black locust ranked also on the first two positions, being followed by sea-buckthorn. This means that these species should be used with priority for afforestation of households dumps when in reclaiming process criteria such as growth rate, root system and soil requirements are of great interest (*i.e.* when the forest manager, land owner or other stakeholder is interested in promoting fast growing shrub and/or tree species, with a well-developed root system and with fewer soil requirements (Figure 2).
When both generative and vegetative regeneration accounted for the highest share within the decision of which species should be used (*i.e.* almost 70%; scenario no. 3), Tree of Heaven, black locust and European ash, as in the case of scenario no. 1, ranked on the first three positions. The less recommended species was manna ash.

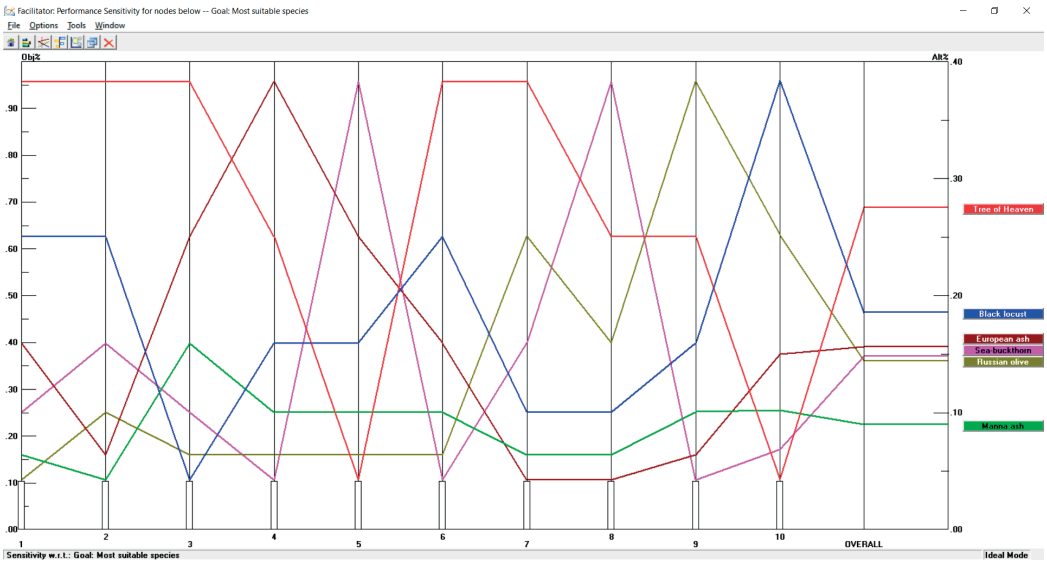

Figure 1. The ranking of the six woody species in the first scenario

In all three cases, Tree of Heaven and black locust resulted to be the best choices for afforestation of household dumps consisting of demolition materials mixed with organic materials.

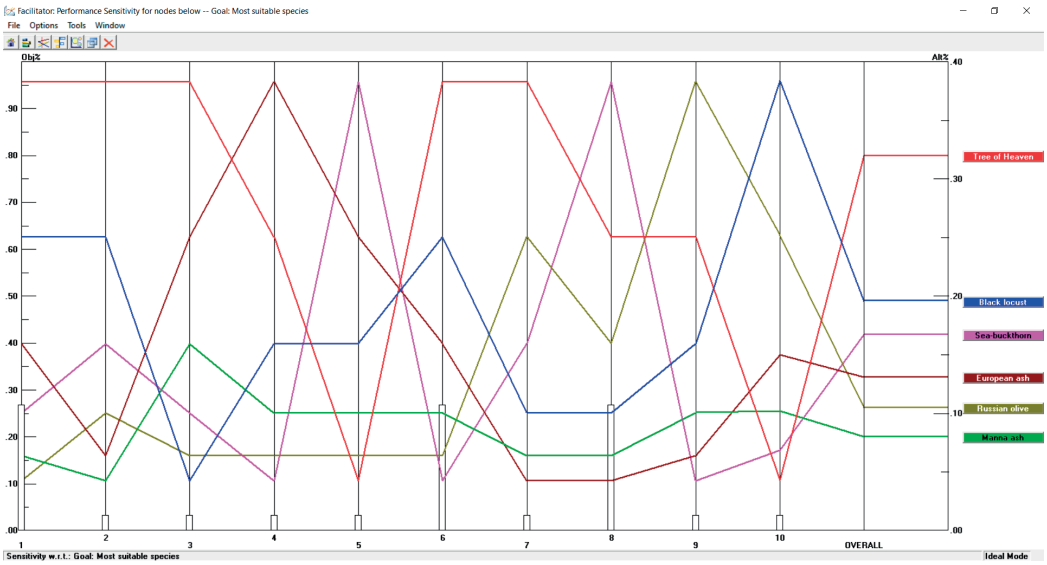

Figure 2. The ranking of the six woody species in the second scenario

CONCLUSIONS

This study should be regarded as an attempt to provide additional criteria that could be considered when someone is planning to select the most suitable woody species out of a diverse combination.

In the perspective of afforestation of a very diverse range of degraded lands corroborated with the desire to grow the green spaces nearby localities, a flexibility in choosing the species that would be planted, but a science-based one, is more than welcome.

Future research should also include criteria that take into consideration aspects regarding functional relations of the future green spaces with the nearby ones, from integrated and sustainable development perspectives.

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