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ALLOCHTHONOUS TREE SPECIES USED FOR AFFORESTATION OF SALT-AFFECTED SOILS IN ROMANIA

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Abstract

In Romania, in the last years, an increasing attention is given to the afforestation of degraded lands. According to recent statistics, across the country there are more than two million hectares of degraded terrains. In most of the cases, the afforestation works are carried out by specialized units and the projects are monitored by the territorial branches of the ministry responsible for forestry (i.e. Forest Guards). The afforestation projects are done based on the technical norms issued by the ministry responsible for forestry (i.e. Ministry of Environment, Waters and Forests). For each type of degraded land, situated in a certain region, one, two or even more alternatives regarding the usage of specific tree and shrub species are proposed. The aim of this study was to highlight the best afforestation solution (i.e. the most suitable allochthonous tree species) of the salt-affected terrains as they are described in the Technical Norms regarding the compositions, schemes and technologies for forest regeneration and afforestation of degraded lands. The best alternative resulted by using an Analytic Hierarchy Process (AHP), that took into account five allochthonous species and ten criteria.

Key words: *afforestation, AHP, allochthonous tree species, degraded lands, salt-affected soils.*

INTRODUCTION

In the last decade, in Romania, several afforestation projects of degraded lands were implemented. In most of the cases, the financial support was given by the Romanian Government, through specialized structures and programs. For example, between 2010 and 2017, more than 130 afforestation projects were financed by the Administration of the Environment Fund (AFM, 2018). Currently, the Agricultural Payments and Intervention Agency is financing afforestation projects, by the dedicated sub-measure 8.1 (APIA, 2019). In addition, the Ministry of Environment, Waters and Forests is providing funds for afforestation of degraded lands through its territorial units specialized in forestry (*i.e.* Forest Guards), following the procedure described by the Government Decision no. 1257/2011 and the Law no. 100/2010.

Across the country, several categories of degraded lands exist, the total area being around 2 million hectares (Șerbănescu, 2007). Among them, the terrains affected by salinity account for 614,000 hectares, of which the highest share is located in Romanian Plain (200,600 hectares), followed by the ones from Western Plain (175,000 hectares), Moldova (114,000 hectares), Dobrogea (104.000 hectares) and Transylvania (20,400 hectares), respectively (Coteț and Eftene, 2009; Bălteanu and Popovici, 2010).

Worldwide, the situation is even worse. It is estimated that the sodicity (or alkalinity) development in the soil is affecting an area of 434 million hectares (Bhardwaj et al., 2019), and more than 40% of the World's land surface may have potential salinity problems (Lal and Khanna, 1994). For example, in India, the salt-affected soils account for 7-10 million hectares, of which 3.6 million hectares are alkali soils (Mishra et al., 2006; Arya and Lohara, 2016). Other countries with large areas of salt-affected soils are Ethiopia and Pakistan, the total area accounting for more than 11 and 6.2 million hectares, respectively (Zaka et al., 2003; Qureshi et al., 2018). In most of the cases, the salt-affected soils frequently appear in arid and semi-arid regions, characterized by a low rainfall and very high temperatures (Abdel-Fattah et al., 2015).

The salt-affected soils are divided into two categories, namely saline soils and sodic (alkali) soils (Gill and Abrol, 1991), the salinization taking place in different ways, such as: on bench-leveled rice plots through the redistribution of salts from a higher plot to a lower one, soil alkalization through microbiological reduction of sulfates in waterlogged, accumulation of salts originating from irrigation water, redistribution of salts from the subsoil to the surface of irrigated lands, rise of saline groundwater in irrigated plots and in nonirrigated adjoining plots (Maianu, 1984; Zhang et al., 2004).

Both primary salinization process (*i.e.* the salt is accumulating through natural processes due to the high salt content of the groundwater or the parent material) and secondary salinization processes (generated by human activities) represent major threats to both agricultural and forest management (Mihalache et al., 2015; Bhardwaj et al., 2019; Cuevas et al., 2019; Safdar et al., 2019; Zhang et al., 2019). For example, agricultural mismanagement of irrigated dry terrains or the vegetation change that influence the salt exchange between the groundwater and the ecosystems represent ones of the main factors of soil salinization (Nosetto et al., 2008; Hbirkou et al., 2011).

Soil salinization represents one of the most severe abiotic stresses affecting plant growth or survival (Jolly et al., 1993; Du et al., 2013; Sugadev et al., 2018; Sugai et al., 2019), seed germination percentages (El Nour et al., 2006; Gu et al., 2012) or different metabolic processes (Yue et al., 2019).

Worldwide, different planting techniques (Tomar 1997; Tomar et al., 1998) and shrub and tree species were tested. Good results were recorded in the case of *Elaeagnus angustifolia* L. in USA (Zalesny et al., 2019), *Prunus armeniaca* L., *Populus nigra* var. *pyramidalis* (Rozan) Spach, *Salix nigra* Marshall, *Thuja orientalis* (L.) Franco, *Populus euphratica* Olivier, *Ulmus pumila* L., *Fraxinus pennsylvanica* Marshall and *Morus alba* L. in Uzbekistan (Khamzina et al., 2006), *Tamarix smyrnensis* Bunge, *Elaeagnus angustifolia* L. and *Populus alba* L. in Turkey (Yildiz et al., 2017), *Eucalyptus* spp. L'Hér in Israel (Ohlde et al., 2019), *Atriplex nummularia* Lindl., *Pinus halepensis* Miller and *Eucalyptus gomphocephala* DC. in Tunisia (Zouari et al., 2019) and *Acer tataricum* L., *Elaeagnus angustifolia* L., *Ulmus pumila* L. in Romania (Enescu, 2015; Enescu, 2018a), respectively.

The aim of this study was to highlight the most suitable allochthonous tree species used in Romania for afforestation of the salt-affected soils.

MATERIALS AND METHODS

Five of the most common allochthonous tree species, namely black locust (*Robinia pseudoacacia* L.), Japanese pagoda tree (*Sophora japonica* L.), honey locust (*Gleditsia triacanthos* L.), Russian olive (*Elaeagnus angustifolia* L.) and Tree of Heaven [*Ailanthus altissima* (Mill.) Swingle] were taken into consideration. These species are among the ones recommended for afforestation of salt-affected lands by the Technical Norms regarding the compositions and technologies for forest regeneration and afforestation of degraded lands.

In order to highlight the most suitable allochthonous species 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 analysed (Enescu, 2018b). A scale ranging from 1 to 5 was used for each criterion, namely:

- **criterion 1** - growth rate (from 1 - very slow growing rate to 5 - very fast growing rate),
- **criterion 2** - vegetative propagation (from 1 - no vegetative propagation to 5 - very intense vegetative propagation),
- **criterion 3** - seed dispersal (from 1 - the smallest to 5 - the highest),
- **criterion 4** - height (from 1 - the smallest to 5 - the highest),
- **criterion 5** - crown density (from 1 - rare crown to 5 - very dense crown),
- **criterion 6** - root system (from 1 - very less developed in depth and sidewise to 5 - very developed in depth and sidewise),
- **criterion 7** - demand for light (from 1 - very shade tolerant to 5 - very high demand for light),
- **criterion 8** - soil requirements (from 1 - extremely low requirements to 5 - very high requirements),
- **criterion 9** - temperature requirements (from 1 - resistant to low temperatures to 5 - resistant to high temperatures) and
- **criterion 10** - ornamental value (from 1 - very low value to 5 - very high value), respectively.

This methodology was used in a similar study aimed at highlighting the shrub species that should be used for establishment of the field shelterbelts in Romania (Enescu, 2018b). For analysing each criterion Expert Choice Desktop software (version 11.5.1683) was used. Two scenarios were taken into consideration, namely scenario 1 (all criteria received an equal share) and scenario 2 (the first two criteria received highest shares, namely 35.1% and 23.3%, respectively).

RESULTS AND DISCUSSIONS

By summarizing the information from specialized manuals and studies, a brief description of the five species was done in accordance with the ten considered criteria.

Black locust is a fast-growing, a very shade intolerant and a thermophilous tree species and it has a very good vegetative propagation system, due to its well-developed roots (Clinovschi, 2005; Şofletea and Curtu, 2008; Rédei et al., 2012; Du et al., 2013; Enescu and Dănescu, 2013).

Japanese pagoda tree has several economic, ornamental and medicinal values. It can reach up to 15-20 m in height, it has a well-developed root system and its seed propagation is very rarely used, the seed pods reaching up to 5 cm in length (Clinovschi, 2005; Kollár, 2012; Sajdak and Velazquez-Marti, 2012; He et al., 2016; Shu et al., 2019).

Honey locust can grow in different degraded terrains, including the salt-affected ones. It prefers the direct exposure to sunlight and a mild climate. It typically reproduces through the production of abundant seeds (Clinovschi, 2005; Vilches et al., 2019).

Russian olive has a rapid juvenile growth rate (Khamzina et al., 2009) and it can be propagated in both vegetative and generative ways (Busso et al., 2013). It has a well-developed root system (Şofletea and Curtu, 2008; Enescu, 2015), it is resistant to drought and frost (Stratu et al., 2016) and it can grow in almost any type of soil (Aksoy and Şahin, 1999), even in salt-affected soils (Katz and Shafroth, 2003).

Tree of Heaven is a shade intolerant species, preferring open spaces and it demands a warm climate, but is resistant to drought as well. This species has a very fast growing rate and the capability to reproduce itself at very early ages, both vegetative and by seeds (Enescu, 2014; Enescu et al., 2016).

The results of the AHP ranking are given in Table 1.

Table 1. AHP alternative ranking

Criterion	*R. pseudoacacia*	*S. japonica*	*G. triacanthos*	*E. angustifolia*	*A. altissima*
1	4	1	3	2	5
2	4	1	2	3	5
3	2	3	1	4	5
4	4	2	5	1	3
5	4	5	3	2	1
6	4	2	3	1	5
7	3	1	2	4	5
8	4	3	5	2	1
9	3	4	2	1	5
10	3	5	2	4	1

According to the results in scenario 1, the most suitable tree species among the five selected was the Tree of Heaven (Figure 1). Its placing in the top is mainly explained by the fact that it is a fast growing species that is easily propagating both on vegetative and generative ways.

In the second scenario, in comparison with the first one, no significant differences were recorded regarding the top two species (*i.e.* Tree of Heaven and black locust). The last three species (*i.e.* Honey locus, Russian olive and Japanese pagoda tree) recorded similar results (Figure 2).

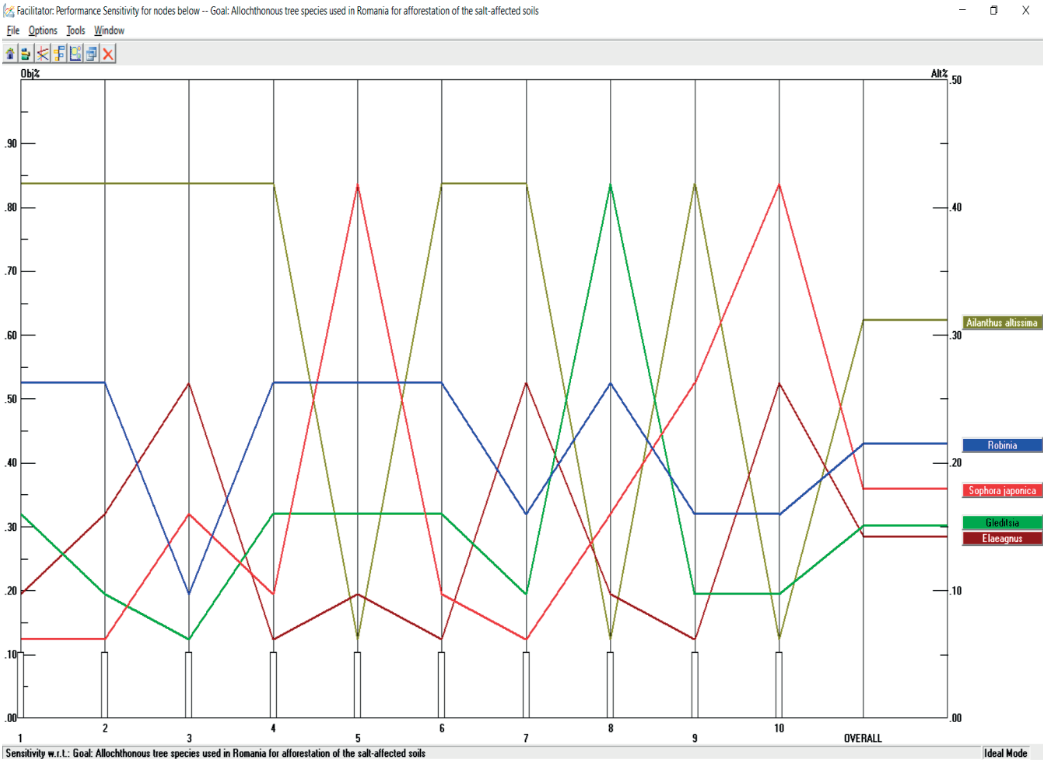

Figure 1. The ranking of the five tree species in the first scenario

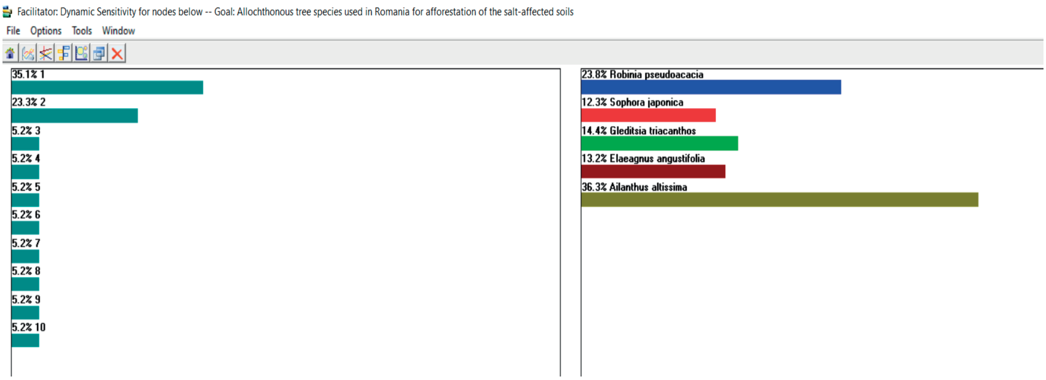

Figure 2. The ranking of the five tree species in the second scenario

CONCLUSIONS

Soil salinity is one of the major threats both in Romania and worldwide. In most of the cases, the salt-affected soils represent the consequence of an improper agricultural management, resulting large areas of degraded soils that could be economically exploited through afforestation.

Romania has great experience in the field of afforestation of degraded lands, by using several shrub and tree species, including the allochthonous ones.

This study that was based on a multi-decision analysis should be regarded as a first step in selecting the most suitable species for afforestation of salt-affected lands. Future research may consider additional criteria in accordance with the targeted scenarios.

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