

DATA ON COAL DUMPS RETRIEVING IN PETROȘANI BASIN USING SEA BUCKTHORN (*HIPPÖPHAE RHAMNOIDES*)

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Abstract. This contribution presents data on the sea buckthorn (*Hippöphae rhamnoides*), with focus on its value on coal dumps retrieving in the Petroșani Basin. Due to its peculiar roots exposing a lot of nodules, this plant has an important role in fixing the atmospheric azoth and soil genesis. It is very adaptable to any kind of soil and has wide climatic exigencies, but is depending on light intensity. It has a large dissemination capacity, due to its light and numerous seeds. Besides its utilization on dump retrieving, sea buckthorn is used in medicine and pharmacy, as well as in organic fuel production.

Keywords: coal dumps, Petroșani Basin, cutting, soil fertilization.

INTRODUCTION

Systematic classification

Kingdom	Vegetable
Phylum	Spermatophyta
Class	Magnoliopsida (Dicotyledonatae)
Order	Elaeagnales
Family	Elaeagnaceae
Genus	Hippöphae
Species	Hippöphae rhamnoides

Ecology and distribution - is native to Central Asia. It grows in clumps or in spread-out shrubs vegetating on sand and gravel, or on pebbles exposed along riverbanks, ponds and rocky hillsides. It prefers saliferous geological formations, from seaside regions to the alpine level. Its range extends over all Europe and Asia, from the Atlantic to the Pacific oceans. It can be found up to the 67°56' parallel (in Norway) and down to the 23°27' parallel (in Asia), thus reaching the Indian Ocean between the Persian Gulf and India and in Europe, the Black Sea shore. In other words, it is spreading on over 180° of longitude and 440° of latitude. From an altitudinal point of view, it reaches heights of 2000 m in Europe, 4500 m in the Tibetan Plateau and 5000 m in the Himalayan Mountains. In Romania it can be found over large areas in Muntenia and Moldavia Carpathian foothills, between Olt and Siret rivers, as well as on the islands in the Danube Delta. The northern limit of its area is on Bistra Valley (Ceahlău commune). Sea buckthorn is extremely resistant to draught and frost. While being able to live in very poor soils, it requires only enough sunlight [4].

It is pioneering, oligotrophic, xerophilic-mezohigrophilic plant, suited for holding down bad lands, ravines and land sliding hill sides. spreads naturally [6].

Due to its increased capacity of root sucker production, sea buckthorn is used for consolidating sloping terrains, or it is cultivated in the form of hedgerows. In some areas, it is used for the benefit of agriculture, as, with its leguminous-like nodosities, it enriches the nitrogen in the soil, whereas, with its production of root suckers, it prevents the soil erosion (**Fig. 1**) [1].

Plant characteristics- grows as 1.5 – 4 m tall thorny shrub. Its maximum stem diameter is 15 cm. Depending on the climatic environments and soil types,



Figure 1. Sea-buckthorn root suckers on Vulcan coal dumps

this plant may develop in two different ways: either as low, creeping shrub in poor soil arid areas, or as 8-10m tall arborescent plants, on fertile soils [2] (**Fig.2**).



Figure 2. Sea-buckthorn on Petrilaocal dumps

The root system is very well developed. The plant has a large capacity of producing root suckers at 20 cm deep in the ground. Nitrogen-fixing nodules similar to

those of leguminous plants are formed on this plant roots. The free bacteria of the *Rhizobium*, *Azotobacter* and *Clostridium* kinds, living into the soil, are producing them. These bacteria penetrate the plant through the absorbing trichomes, being attracted by root-secreted flavones and settle inside the root, where they form nod-like globular formations. The latter's appearance is favored by the presence of microelements such as boron, molybdenum, calcium and sulphur. The bacteria develop and multiply inside the nodules, while they fix atmospheric nitrogen, making it assimilable. While the bacteria appropriate sugars and other kinds of substances they are unable to synthesize from the plant, the, in its turn, makes use of the organically nitrogen the bacteria fix [3]. *Azotobacter* is considered an indicator of ecologic features into a soil [8].

Sea-buckthorn's stem has a fine, dark-colored crust, with an either furrowed, or fibriform – in the base of old shrubs – ritidome. The intensely ramified tree crown seems thick; however, it does not spread enough shadow on the ground. has got a lot of very sharp, strong lignified thorns. The buds are foliaceous, small, spherical, presenting two trichome-covered scales. Floral buds are large and have numerous reddish-brown coloured scales. The leaves are caduceus, alternate, small, short petiolated, linear to spear-shaped. They have narrow, 4-6 cm long limb and a single rib. Their edges are whole. The scaly trichomes of grey-silvery color on the leaves gave the plant its traditional name in Rumanian – “cătina albă” – “white sea buckthorn”. The leaves lack stipule, but they are rich in vitamin C [6].

The flowers are dioecious, axillary, small, greenish-white, disposed in racemes and hidden among leaves, the emergence of which they precede. Male plants are more vigorous than the female ones. These have longer and thicker, dark-coloured yearly branches and larger buds. Male flowers have two sepals and four stamens; they are disposed in globulous inflorescences. Female flowers are tubulous, with a short pedicle, disposed in spiciform racemes; the style is filiform, the stigma cylindrical, the ovary superior.

The fruit is pseudoberry or false stone fruit, small, oval-shaped, fleshy, 0.7-0.8 cm in length. Its dominant color is orange, passing towards yellow. Red fruits are rare. Numerous and disposed one next to the other, the fruits dress the branches the way a muff would do. The fruits' pulp may be yellow or orange; it is very juicy and the stains it leaves are oily. Sea buckthorn's fruits have a pleasant, aromatic smell. They are not fit for consumption while fresh, as they are sour and astringent. When they reach full ripeness, their acidity is much decreased and they acquire a special aroma, which is stronger when harvesting takes place after a frost.

Sea-buckthorn blooms for 15 days in April-May, when the average temperature during the day is 12-15°C. Male plants flower earlier, while the female plants' blooming takes place at the same time with their foliation. Wind and insects do pollination. At the end of the flowering period, the female flowers that have been pollinated pass into fruits. While the plant bears fruit yearly, this happens in abundance only after 4-5 years of its life. The fruits appear on the two-year-old branches, especially at their top.

Ageing of fruits begins in the first weeks of August. They turn yellow, while the seed is completely formed and capable to germ. The tegument colors as well as that of the pulp intensify, the fruits becoming larger. At the end of September and the beginning of October the fruits reach complete ripeness. If harvest takes place later, the quality of fruits depreciates, as they crack and lose some of their juice [2].

On plantations, sea-buckthorn harvest starts in its third year. During the optimal production period, harvested quantities may exceed 25 tons/ha. After 18-20 years, begins declining, there is little vegetative growth, production is reduced while plants begin to dry either partially, or totally [1].

MATERIALS AND METHODS

Pedo- climatical requirements- grows in mountain, foothill and plain areas. It is able to withstand temperatures down to -35°C, as well as excessive high temperatures of up to +45°C. Nevertheless, it needs light, thus the best harvests are obtained in areas that offer the plant direct exposure to the sun.

This plant can adapt to any kind of soil, be it dried, chernozem or brownish-red. It can grow on saline soils, which have been treated with gypsum, phosphogypsum, aluminium sulphate, calcium chloride, calcium carbonate.

In some areas where soil is very poor – as for example inside the former precincts of Uricani coal aftertreatment station, chemical fertilizers are used in accordance with the *Technical project for closing and ecologisation of the objective Uricani Coal Aftertreatment Station* issued in July 2005 in the following proportions: N- 70-80 kg/ha/arable terrain, P₂O₅- 50-65 kg/ha/arable terrain, K₂O- 65-70 kg/ha/arable terrain; 3 years after planting, 20-30 t/ha of dung are added. On these terrains, workings with the “*paraplău*” (an arrow-shaped plough, that lifts the furrow without turning it over) are undergone. If the soil is maintained as fallow land, the dung is buried at an appropriate depth, immediately after being scattered.

In Romania, the is the species with the greatest ecological amplitude, as it forms woods (**Fig. 3**) and because it is able to vegetate vigorously on various lands.



Figure 3. Sea-buckthorn woods on Ileana coal dumps, in Lupeni

It can be found in the following badlands:

- flysch formations (e.g. the Sinaia Formation) made of blackish carbonate sandstone and black silt and clay, well exposed in Prahova Valley, at Posada;
- Barremian marl (from Cormarnic, Prahova Valley) or on red and green Maastrichtian clay in Belia and Breaza;
- the white sand formed on the Kliwa Sandstone in Pătărlage, on Buzau Valley;
- red – either moist, dry or in between – clay and on compact loess on Siret Coast;
- on fluvial-marine sand of the Danube Delta sand bank at Rosetti and on the Black Sea shore at Cardon, Periteasca- Leahova, Sf. Gheorghe;
- on the former coal dumps made up of clay, marl, sandstone, argillaceous sandstone in Vulcan and elsewhere in the Petroșani Basin (Fig. 4) [2].



Figure 4. A and B : Sea-buckthorn on Ileana coal dumps

Multiplication of sea-buckthorn. Cutting propagation is a vegetative propagation method by which parts of the branches or shoots are put to root under optimal, controlled conditions, after being separated from their mother plant. The cutting may be 18-22 cm long, with a base diameter of 6-10 mm. Depending on the age of the separated fragment, we are able to discern the cutting in dry, for which branches older than 1 year are used. Cutting in green is done with green plants. This is done during the Summer months, especially during June-July. Young branches are grown inside solariums with artificial fog, where substances contributing to their rooting may be added (auxin).

Root suckering or production of sprout directly from an adventitious bud at the level of the hypocotyl. Sea-buckthorn's increased production of root suckers enables them to be harvested and used directly for planting. Young root suckers often have a poorly developed radicular system, which is the reason for the low efficiency of such planting. Before the root suckers are planted, the land needs to be fertilized.

Layering represents a reproduction method quite similar to cutting except for the sprout not being detached from the mother plant. It is a reproduction method most often used for vine. Sea-buckthorn is best suited for hilling layering. The technique employed is the classic one. The hill is usually taken apart after 2 years, when the layers are fast root and a number of 10-12 layers can be obtained from a plant.

Sea buckthorn seed are capable of germination the moment the fruit has begun changing its color from yellow to orange. The more ripe a fruit, the greater its power of germination. For the seeds extraction, the fruits are crushed, pressed through a thick sieve in order to be separated from the protecting covering.

Compared to cutting and layering, this method has the disadvantage of de-purifying breed, for the seeds are well washed, dried in a shaded, draughty place, after which they are kept in cloth bags till the day of their seeding. 80-90 g of seed are obtained from one kilogram of fruit. Better results are obtained when seeding is done at Spring.

The land meant for seeding needs to be clean, with light, minced soil which has been fertilized. Before being sown, the seeds are stratified for 30 days in sand or wet earth, at temperatures of 3-5 °C. For better results, the method of softening the seeds by keeping them in clean water at room temperature for 30 hours before their sowing is sometimes applied.

After being taken out of the water, the seeds are disinfected either in a potassium permanganate (KMnO_7) solution for 10 minutes, or, more complicated, at 70°C for 3-4 days. Although the thermic method is much more expensive, it is preferable when we are not sure of the biological material we have at our disposal.

The chemical disinfection with permanganate is efficient against fungus and bacteria, inefficient against possible viral infections.

Grafting is done mainly with wooden species – trees and shrubs. It is a propagating method for the more valuable breeds [9, 10, 11].

RESULTS AND DISCUSSIONS

On sloped terrains endangered by erosion, triangular-shaped planting areas are commonly used, with the point of the triangle such trended as to correspond to the land's peak, and in such a way that the trees of the even-number lines be sown at the middle of the distance between the trees of the odd-number lines. Thus, a mosaic pattern plantation results, which is specific to erosion control actions.

On plain areas, the tree lines direction must be chosen in such a way that plants get as much sunlight as possible. On full sandy fields with desertification tendencies, sea-buckthorn is sown in holes 20-30cm deep.

Sowing of seedlings is done either in autumn or in spring times. However, the former possibility is preferable, due to several reasons: the sowing period is longer, the temperatures are milder and rainfall accumulates into the soil, which enables the shaping roots to cicatrize and make contact between them and the particles in the soil. This method's efficiency is almost 100%.

Starting in the eight decade of the former century, in association with other nitrogen-fixing plants were sown on the coal dumps of the pits or mines in USA, Germany, Russia, Romania [7, 8].

In Romania, Biro made an experiment between 1987-1997, sowing on the coal dumps in Petroșani Basin, on the Put 7 West dump, inside the Vulcan mine perimeter, with its 6.3 ha surface. was planted together with another 2 species: *Pinus sylvestris* and *Robinia pseudacacia* directly on the dirt extended on 5 ha, without arranging the terrain with imported soil and any other amendments. Species grouping was done in 30 m alternate strips on the contour line, being planted especially on surfaces with slopes exceeding 350, in rut and along them. No maintaining works were undergone, except for replacing loses with cuttings obtained from mature exemplars of *Hippöphae rhamnoides*.

From physical-geographical point of view, the coal dump is situated between 635-710 m in altitude; the deposit was created on a rolling versant with an average pending of 280 and a West North-West exposure. It is part of the subalpine beechwood level.

The climate concerns 5.20 C annual average temperature and 822.6 mm average annual rainfall.

Soil analysis at the beginning of the experiment stressed out traces of humus, while, at the end of the experiment, there were already installed tendencies towards soil profile differentiation.

Statistic data shows that the largest losses with all the 3 species were registered in the first year of vegetation. During the second year, the reduced vitality of *Pinus sylvestris* and *Robinia pseudacacia* was observed, so their planting had been abandoned. The remaining losses were completed with cuttings of *Hippöphae rhamnoides*, taken from the remaining trees of its kind and planted in the clefts.

Starting with the third year of vegetation, artificial filling was not necessary any more, as the natural growth of *Hippöphae rhamnoides* – a result of root

suckering, layering and sprouting brought a solution to this problem.

Due to its outstanding features, *Hippöphae rhamnoides* came to a considerable density in 1995 (5000 saplings/ha), showing rising dynamic than the other species, which had been drastically reduced.

In the seventh year from its plantation, the culture can be considered succeeded, developing anti-erosion and soil-forming influences.

The attempts at cutting propagation done on coal dumps in identical conditions proved to be a failure. In the first year of vegetation, approximately 100% of the cuttings grew roots, in the second year shoots grew up to 20cm, while during the third year the entire culture was withered. When withered plants were examined, it was observed that the nodosities containing bacteria that fix atmospheric nitrogen did not exist on their roots. It must be mentioned that cutting propagation with lignified cuttings of can only be done when there has been some anterior planting with seedlings of the same species, which had presented nodosities on their roots thus having insured the infestation of soil with nodosity-specific bacteria.

Mușat in 1995 carried on similar research on the coal dumps in Motru-Rovinari Basin [8].

Sea-buckthorn importance: This plant fruit contains twice as much vitamin C as those of the hawthorn and 10 times as much as the citric fruits. In ripe fruits, the juice excels 400-800mg at 100g of fresh juice. Other vitamins inside the fruit are A, B1, B2, B6, B9, E, K, P and F. There is also cellulose, beta-carotene (significantly more than in carrot pulp), microelements such as phosphorous, calcium, magnesium, potassium, iron and sodium, complex oils etc [9, 10, 11].

Sea buckthorn wood and bark represent a superior fuel according to the following data: alburnum l- 5000 kcal/kg, altered duramater 5400 kcal/kg, the bark - 5720 kcal/kg (compared to 4062 for the hornbeam, 4187 kcal/kg for the beech, and approximately 4390 kcal/kg for the oak. Analysis also demonstratead that sea buckthorn wood, by comparison with that of the beech, gave the following results (calculated for completely dried wood): cellulose – 48.01% compared to 67.09%; lignin 28.87 compared to 22.46%; alcohol-benzen extract (1: 1), 1.99%; ash – 0.16% compared to 0.40%. In what the ash content is concerned, it has been observed that the oak duramater has got 0.16%, too, while that of the pine 0.15% and that of larch 0.12%

In China, sea buckthorn is used in treating some digestive affection. Other affections that this plant can help treating are the ophthalmologic and coronary ones, high blood pressure, gingivitis, epidermal hepatitis, chronically hepatitis, alcoholism, gout, rheumatism, liver cirrhosis, atherosclerosis, anemia; external use: burns, frostbites, radiation. [4].

Sea buckthorn also inhibits appetite if part of a treatment against obesity [5].

Very appreciated products are obtained by the fruits' processing: juice, nectar, syrup, jam, jelly, marmalade, liqueur, various kinds of alcoholic drinks.

CONCLUSIONS

Sea buckthorn is a pioneering species with a clear role in fixing atmospheric nitrogen, increasing soil fertility, stopping the pluvial erosion process and obvious value in coal dumps rehabilitation.

This plant has a high capacity of dissemination, producing plenty of light seed. It is employed in pharmacy, medicine and in the food industry.

Due to its high caloric power, sea buckthorn is used as fuel, and in the past 20 years, the creation of some different cultures in various areas of the country has been observed. Unfortunately, excessive grubbing has been registered, too, in some mountain, hill and plain regions.

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